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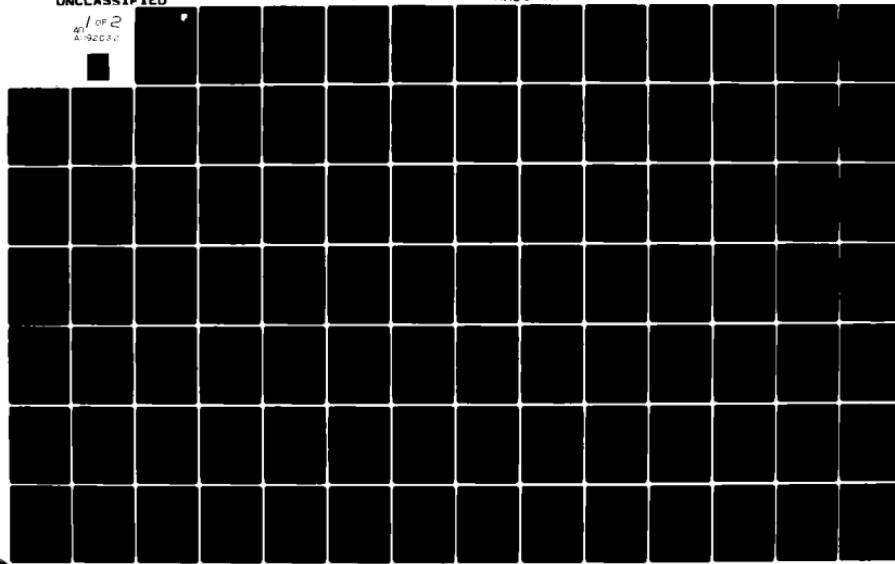
EVALUATION OF TIME DOMAIN EM COUPLING TECHNIQUES, VOLUME II.(U)
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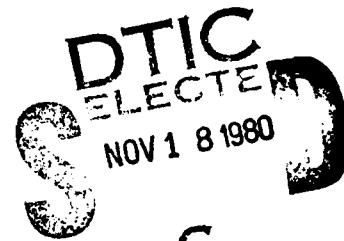
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EVALUATION OF TIME DOMAIN EM COUPLING TECHNIQUES

IIT Research Institute

Dr. Allen Taflove



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Air Force Systems Command
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This research program investigated a new tool for the analysis of electromagnetic coupling and shielding problems: the finite-difference, time-domain (FD-TD) solution of Maxwell's equations. The objective of the program was to evaluate the suitability of the FD-TD method to determine the amount of electromagnetic coupling through an aperture into an enclosed conducting container and the interaction and coupling of the penetrating fields with internal electronics. Two specific container			

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models were used for the evaluation. The first, a conducting cylinder with one open end; the other, the guidance section of a missile. Each of these two configurations was modeled to calculate the electromagnetic field occupied into the structure.

The following specific questions were addressed during this program:

1. Can the FD-TD method accurately model electromagnetic coupling into a conducting structure for arbitrary angles of incidence and arbitrary wave polarization?
2. Can the FD-TD method accurately model a complex structure with both irregular-shaped apertures and dielectric or permeable materials within the interior?
3. Can the FD-TD method predict the voltage, current, or power that the coupled field may induce on wires or cable bundles inside of a metal structure?

4. What are the size limits of an object that can be modeled using the FD-TD method?

5. What is the capability of the FD-TD method to interface with other analysis techniques, such as "Method of Moments?

Overall, this program showed that the FD-TD method can be successfully applied to electromagnetic coupling problems involving conducting structures with hole and sleeve-type apertures illuminated by a plane wave having an arbitrary polarization and angle of incidence. Further, the FD-TD method can be applied to complex cavity-like structures having internal metal and dielectric materials, as well as connecting wires. Accuracy of the FD-TD results was very good relative to the uncertainties of available experimental and numerical-theory approaches. Convergence of the electromagnetic fields to the sinusoidal steady state occurred within about 3 cycles of the incident wave when a slight value of isotropic loss was assigned to the interior of the structures modeled. This resulted in program central processor times of less than 5 minutes for FD-TD lattices containing as many as 1.5 million unknowns time-stepped to $n_{max} = 800$ using the Control Data STAR-100 and Cyber 203 computers.

This program also established the feasibility of a hybrid MOM/FD-TD analysis technique based upon the use of Schelkunoff's equivalent electric current theorem at apertures of a cavity. This hybrid technique was shown to give consistent results for apertures strongly coupled to internal wires or other metal and dielectric structures.

This program has shown that the pure FD-TD and hybrid MOM/FD-TD methods have great promise for applications involving complex conducting and dielectric structures illuminated by plane waves at arbitrary angles of incidence and polarization. Further, great promise is shown for those structures that are simultaneously electrically large compared to a wavelength and penetrated by locally complex cavity-backed apertures having dimensions comparable to a wavelength. Such structures requiring resolution of both large and small details at the same time have not been well treated by any one previous analytical or numerical approach.

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PREFACE

IIT Research Institute (IITRI) is pleased to submit this Final Report on "Evaluation of Time Domain Electromagnetic Coupling Techniques" to Rome Air Development Center (RADC/RBCT). The report covers work performed by IITRI under Air Force Contract No. F30602-79-C-0039, designated as IITRI Project No. E6461. The report is in two volumes. Volume 1 covers details of the technical work, including relevant theory and numerical results. Volume 2 provides listings of the Fortran computer programs used to obtain the results of Volume 1.

The principal investigator on this program was Dr. Allen Taflove, with support provided by Dr. Korada Umashankar of IITRI on Task 5; Mr. Neil Robertson of IITRI on data reduction and contour map plotting; and Prof. Donald Wilton and Dr. Allen Glisson of the University of Mississippi on computation of frequency-domain data for checking of results and for Task 5. The project duration was 7 December 1978 to 29 February 1980.

Respectfully submitted,
IIT RESEARCH INSTITUTE

Allen Taflove

Allen Taflove, Ph.D.
Research Engineer

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VOLUME 2 - LISTINGS OF FORTRAN COMPUTER PROGRAMS

1.0 INTRODUCTION

This volume documents the FD-TD computer programs written during the present research effort. Included are listings of the programs for the following problems:

- A. Penetration of a 19.0 cm diameter, 68.5 cm long, open-ended aluminum cylinder by a 300 MHz plane wave at broadside incidence and TE polarization (Section 3.1 of Volume 1);
- B. Same as Problem A, but for TM polarization (Section 3.2 of Volume 1);
- C. Penetration of a 12.8 cm diameter, 28 cm long, missile guidance section by a 300 MHz plane wave at axial incidence, for the case of the interior dielectric components modeled (Section 4.1 of Volume 1);
- D. Same as Problem C, but for the case of the interior dielectric and metal components and wires modeled (Section 4.2 of Volume 1);
- E. Hybrid method of moments/FD-TD analysis of penetration of a 19.0 cm diameter, 68.5 cm long, open-ended aluminum cylinder by a 300 MHz plane wave at axial incidence (Section 7.4.1 of Volume 1);
- F. Same as Problem E, but for TM polarization of the incident wave at 45° incidence relative to the cylinder axis (Section 7.4.2 of Volume 1);
- G. Hybrid method of moments/FD-TD analysis of loaded missile guidance section of Problem D (Section 7.4.3 of Volume 1).

The computer program listings for Problems A and B were run without requiring any data cards, since the descriptions of the cylinder geometries employed are contained within the programs. Program listings for Problems C, D, E, F, and G required data-cards decks of sizes 720 cards, 720 cards, 72 cards, 72 cards, and 528 cards, respectively, to specify the interaction geometry. The data-card format for these programs is summarized in Section 3.1 of this volume. Further, program listings for Problems E, F, and G required data-card decks of sizes 144 cards, 288 cards, and 225 cards, respectively, to specify the aperture excitation for the hybrid method of moments/FD-TD approach. The data-card format for this specification is summarized in Section 3.2 of this volume.

All FD-TD computer programs were written using STAR Fortran Version 2.1 for processing by the Control Data STAR-100 or Cyber 203 computer systems under the 1.2 operating system. This Fortran version contains certain extensions to ANSI standard Fortran [1] that permit usage of the vector processing capabilities of these computers. The reader is referred to the STAR Fortran Manual for detailed discussion of these features [2].

2.0 FD-TD PROGRAM LISTINGS

In each of the programs of this section, FREQ = 3.0 E + 8 denotes the operating frequency, f = 300 MHz; DX denotes the lattice cell size, δ (in meters); MPR denotes the total number of media within the model; DATA EPS and DATA SIG give the assumed relative dielectric constant and conductivity (mhos/m) of each medium; and NMAX gives the number of the last time step of the algorithm.

2.1 Problem A -- Task 1, Case 1 (Section 3.1 of Volume 1)

The following 11 pages list the computer program for the 159 x 64 x 24 cell -- 800 time step run of Problem A. The problem solved is penetration of a 19.0 cm diameter, 68.5 cm long, open-ended aluminum cylinder by a 300 MHz plane wave at broadside incidence and TE polarization.

PROGRAM FDTD(INPUT,OUTPUT,TAPE60=INPUT,TAPE8=TAPE8)

C RUN TASK1-- STEADY 300 MHZ PLANE WAVE IRRADIATION OF A
C 19.0 CM DIAMETER, 68.5 CM LONG, OPEN-ENDED
C ALUMINUM CYLINDER

C CASE I- TE POLARIZATION OF THE INCIDENT WAVE
C BROADSIDE INCIDENCE

C INCIDENT WAVE COMPONENTS EZ AND HX
C 159 X 64 X 24 CELL CUBIC SPACE LATTICE IS USED
C UNIT CELL DIAMETER = DX = 0.5 CM = WAVELENGTH/200
C EVEN SYMMETRY ABOUT LATTICE PLANE Z = 24*DX IS ASSUMED
C SOFT TEM WAVE SOURCE CONDITION IS USED AT PLANE Y = 3.0*DX
C SOFT LATTICE TRUNCATIONS ARE USED
C PROGRAM IS OPTIMIZED FOR THE CDC STAR-100

REAL MUR,MUZ
DIMENSION A(2422500), A1(3840),A2(3840),AAL(3840),
1 AAR(3840), DD(160),AL(24),AR(24),CA(9),
2 CB(9),EPS(3),SIG(3), KEXB(19),KEXC(19)

COMMON A
DESCRIPTOR D1,D2,O3,D4,NFD,BV,BW,BX,BY,A1X,A2X,A1Y,A2Y,A1Z,
1 A2Z
BIT BV,BBB(3840),BW,BBW(3840),BX,BBX(3840),BY,BBY(159)
ASSIGN A1X,A1(162;3678)
ASSIGN A2X,A2(162;3678)
ASSIGN A1Y,A1(161;3679)
ASSIGN A2Y,A2(161;3679)
ASSIGN A1Z,A1(1;3839)
ASSIGN A2Z,A2(1;3839)
ASSIGN BW,BBW(1;3840)
ASSIGN BX,BBX(1;3840)
ASSIGN BY,BBY(1;159)
ASSIGN D4,DD(1;159)
T1 = SECOND(CP)
PRINT 150, T1
150 FORMAT(F20.5)

.....I. PROBLEM PARAMETERS.....
FREQ = 3.0E+8
DX = 0.005
MPR = 3
DATA EPS/1.0, 1.0, 1.0/
DATA SIG/0.0, 3.7E+7, 0.01/
NMAX = 800

.....CYLINDER GEOMETRY DESCRIPTION.....
DATA KEXB/19,17,15,13,12,11,10,9,9,8,8,7,7,7,6,6,6,6,6/
DATA KEXC/25,19,17,15,13,12,11,10,9,9,8,8,7,7,7,6,6,6,6/

.....II. BASIC AND DERIVED CONSTANTS.....
PI = 3.141592e5
MIZ = 4.0 * PI * 1.0E-7
EIZ = 8.854E-12

```

DT = 0X / 6.0E+8
NHALF = 0.5 / FREQ / DT
R = DT / 2.0 / EPSZ
RA = DT**2 / DX**2 / MUZ / EPSZ
RB = DT / DX / MUZ
RC = 1.0E+4 / RB
RD = 2.0 * PI * FREQ * DT
IPUN = 0
C
A1(1;3840) = 0.
A2(1;3840) = 0.
CA(1;9) = 0.
CB(1;9) = 0.
BW = Q8VMK0(1,160;BW)
BX = Q8VMK2(159,160;BX)
DO 2 I=1,MPR
EAF = R * SIG(I) / EPS(I)
CA(I) = (1.0-EAF) / (1.0+EAF)
2 CB(I) = RA / EPS(I) / (1.0+EAF)
C
C      .....III. LOAD VECTOR A.....
C      .....ZERO INITIAL FIELDS.....
DO 3 I=1,65
IDEL = (I-1) * 36900
3 A(IDEL+1;36900) = 0.
A(2398501;24000) = 0.
C
C      .....TYPE OF MEDIUM.....
C      .....ANISOTROPIC LOSSY AIR.....
DO 4 I=2,64
IDEL = (I-1) * 36900
A(IDEL+1;3840) = 3.
A(IDEL+8161;3840) = 3.
4 A(IDEL+16321;3840) = 1.
C
C      .....BROADSIDE CIRCULAR CYLINDER.....
DO 14 I=15,33
IDEL = (I-1) * 36900
KB = KEXB(I-14)
KC = KEXC(I-14)
DO 7 K=KB,KC
7 A(IDEL+12+(K-1)*160;137) = 2.
C
A(IDEL+8171+(KB-1)*160;138) = 2.
DO 10 K=KB,24
10 A(IDEL+8308+(K-1)*160) = 2.
C
KC = KEXC(I-14) - 1
DO 12 K=KB,KC
12 A(IDEL+16331+(K-1)*160;138) = 2.
KD = KC + 1
DO 13 K=KD,24
A(IDEL+16331+(K-1)*160;137) = 3.

```

```

13 A(IDEL+16468+(K-1)*160) = 2.
C
IA = 67 - I
IDEA = (IA-1) * 36900
A(IDEA+1;3840) = A(IDEL+1;3840)
A(IDEA+16321;3840) = A(IDEL+16321;3840)
IB = 66 - I
IDEI = (IB-1) * 36900
14 A(IDEI+8161;3840) = A(IDEL+8161;3840)
C
T2 = SECOND(CP)
PRINT 150,T2
C
C      ....IV. TIME-STEPPING LOOP.....
DO 200 N=1,NMAX
TERM = SIN(FLOAT(N)*RD) * RB
MCALL = 3 + IFIX(FLOAT(N)/6.0)
IF(MCALL.GT.21)MCALL=21
C
C      ....TRANSVERSE PLANE NO. 1.....
C      ....EX, EZ TRUNCATIONS.....
A(4001;4000) = A(1;4000)
A(1;4000) = A(40901;4000)
A(20321;4000) = A(16321;4000)
A(16321;4000) = A(57221;4000)
C
C      ....EY ITERATION.....
ASSIGN D1,.DYN.3679
ASSIGN D2,.DYN.3679
ASSIGN D3,.DYN.3679
A(12161) = 0.5 * (A(16161)+A(16162))
A(12162;157) = 0.333 * (A(16161;157)+A(16162;157)
1                           +A(16163;157))
A(12319) = 0.5 * (A(16318)+A(16319))
A(16161;159) = A(12321;159)
D1 = CA(3) * A(12321;3679)
D2 = A(24641;3679) - A(24481;3679) + A(33011;3679)
1                           - A(33012;3679)
D3 = CB(3) * D2
A(12321;3679) = D1 + D3
FREE
C
C      ....TRANSVERSE PLANES 2-64.....
DO 82 JY=1,MCALL
JDEL = (JY-1) * 110700
C
C      ....EX ITERATION.....
ASSIGN D1,.DYN.3678
ASSIGN D2,.DYN.3678
ASSIGN D3,.DYN.3678
ASSIGN NFD,.DYN.3678
ASSIGN BV,BBB(1;3678)
C

```

DO 30 MA=1,3
M = JDEL + 36900*(MA-1)

C
C SOFT LATTICE TRUNCATION. . . .
A(40902+M) = 0.5 * (A(44902+M)+A(44903+M))
A(40903+M;156) = 0.333 * (A(44902+M;156)+A(44903+M;156)
1 + A(44904+M;156))
A(41059+M) = 0.5 * (A(45058+M)+A(45059+M))
A(44902+M;158) = A(41062+M;158)

C
C MAIN EX LOOPS. . . .
NFD = A(37062+M;3678)
DO 22 JJ=1,MPR
BV = NFD.EQ.JJ
A1X = Q8VCTRL(CA(JJ),BV;A1X)
22 A2X = Q8VCTRL(CB(JJ),BV;A2X)
D1 = A1X * A(41062+M;3678)
D2 = A(69912+M;3678) - A(33012+M;3678) + A(65542+M;3678)
1 - A(65702+M;3678)
D3 = A2X * D2
30 A(41062+M;3678) = D1 + D3
FREE

C
C EY ITERATION. . . .
ASSIGN D1,.DYN.3679
ASSIGN D2,.DYN.3679
ASSIGN D3,.DYN.3679
ASSIGN NFD,.DYN.3679
ASSIGN BV,BBB(1;3679)

C
DO 40 MA=1,3
M = JDEL + 36900*(MA-1)
C
C SOFT LATTICE TRUNCATION. . . .
A(49061+M) = 0.5 * (A(53061+M)+A(53062+M))
A(49062+M;157) = 0.333 * (A(53061+M;157)+A(53062+M;157)
1 + A(53063+M;157))
A(49219+M) = 0.5 * (A(53218+M)+A(53219+M))
A(53061+M;159) = A(49221+M;159)

C
C MAIN EY LOOPS. . . .
NFD = A(45221+M;3679)
DO 32 JJ=1,MPR
BV = NFD.EQ.JJ
A1Y = Q8VCTRL(CA(JJ),BV;A1Y)
32 A2Y = Q8VCTRL(CB(JJ),BV;A2Y)
D1 = A1Y * A(49221+M;3679)
D2 = A(61541+M;3679) - A(61381+M;3679) + A(69911+M;3679)
1 - A(69912+M;3679)
D3 = A2Y * D2
40 A(49221+M;3679) = D1 + D3
FREE

C

```

C      .....EZ ITERATION.....
ASSIGN D1,.DYN.3839
ASSIGN D2,.DYN.3839
ASSIGN D3,.DYN.3839
ASSIGN NFD,.DYN.3839
ASSIGN BV,BBB(1;3839)

C      DO 50 MA=1,3
M = JDEL + 36900*(MA-1)

C      .....MAIN EZ LOOPS.....
NFD = A(53221+M;3839)
DO 42 JJ=1,MPR
BV = NFD.EQ.JJ
A1Z = Q8VCTRL(CA(JJ),BV;A1Z)
42 A2Z = Q8VCTRL(CB(JJ),BV;A2Z)
D1 = A1Z * A(57221+M;3839)
D2 = A(65542+M;3839) - A(65541+M;3839) + A(24481+M;3839)
1                               - A(61381+M;3839)
D3 = A2Z * D2
A(57221+M;3839) = D1 + D3

C      .....EZ SOFT TEM WAVE SOURCE CONDITION.....
IF(JY.GE.2.OR.MA.LE.2)GO TO 47
A(131021;3839) = TERM + A(131021;3839)

C      .....EZ HOR. PLANE ENVELOPE COMPUTATION.....
47 D4 = VABS(A(60901+M;159);D4)
BY = D4.GT.A(61221+M;159)
50 A(61221+M;159) = Q8VCTRL(D4,BY;A(61221+M;159))

C      .....HX ITERATION.....
DO 60 MA=1,3
M = JDEL + 36900*(MA-1)

C      .....MAIN HX LOOPS.....
D1 = A(24481+M;3839)
D2 = A(12321+M;3839) - A(12161+M;3839) + A(20321+M;3839)
1                               - A(57221+M;3839)
A(24481+M;3839) = D1 + D2

C      .....HX HOR. PLANE ENVELOPE COMPUTATION.....
D4 = VABS(A(28161+M;159);D4)
BY = D4.GT.A(28481+M;159)
60 A(28481+M;159) = Q8VCTRL(D4,BY;A(28481+M;159))
FREE

C      .....HY ITERATION.....
ASSIGN D1,.DYN.3838
ASSIGN D2,.DYN.3838

C      DO 70 MA=1,3
M = JDEL + 36900*(MA-1)

```

```

C
C      ....SOFT LATTICE TRUNCATIONS.....
C      ....LEFT TRUNCATION.....
AL(1) = 0.5 * (A(69541+M)+A(69542+M))
AL(2;22) = 0.333 * (A(69541+M;22)+A(69542+M;22)
1                                +A(69543+M;22))
AL(24) = 0.333 * (A(69563+M)+2.0*A(69564+M))
AAL(1;3840) = Q8VXPND(AL(1;24),BW;AAL(1;3840))
A(69541+M;24) = Q8VCMPRS(A(65542+M;3840),BW;A(69541+M;24))
C
C      ....RIGHT TRUNCATION.....
AR(1) = 0.5 * (A(69566+M)+A(69567+M))
AR(2;22) = 0.333 * (A(69566+M;22)+A(69567+M;22)
1                                +A(69568+M;22))
AR(24) = 0.333 * (A(69588+M)+2.0*A(69589+M))
AAR(1;3840) = Q8VXPND(AR(1;24),BX;AAR(1;3840))
A(69566+M;24) = Q8VCMPRS(A(65540+M;3840),BX;A(69566+M;24))
C
C      ....MAIN HY LOOPS.....
D1 = A(65542+M;3838)
D2 = A(57222+M;3838) - A(57221+M;3838) + A(40902+M;3838)
1                                - A(41062+M;3838)
A(65542+M;3838) = D1 + D2
C
A(65541+M;3840) = Q8VCTRL(AAL(1;3840),BW;A(65541+M;3840))
A(65541+M;3840) = Q8VCTRL(AAR(1;3840),BX;A(65541+M;3840))
C
C      ....HY HOR. PLANE ENVELOPE COMPUTATION.....
D4 = VABS(A(69221+M;159);D4)
BY = D4.GT.A(69591+M;159)
70 A(69591+M;159) = Q8VCTRL(D4,BY;A(69591+M;159))
FREE
C
C      ....HZ ITERATION.....
ASSIGN D1,.DYN.3678
ASSIGN D2,.DYN.3678
C
DO 80 MA=1,3
M = JDEL + 36900*(MA-1)
C
C      ....SOFT LATTICE TRUNCATIONS.....
C      ....LEFT TRUNCATION.....
AL(2) = 0.5 * (A(36852+M)+A(36853+M))
AL(3;21) = 0.333 * (A(36852+M;21)+A(36853+M;21)
1                                +A(36854+M;21))
AL(24) = 0.5 * (A(36873+M)+A(36874+M))
AAL(1;3840) = Q8VXPND(AL(1;24),BW;AAL(1;3840))
A(36851+M;24) = Q8VCMPRS(A(32852+M;3840),BW;A(36851+M;24))
C
C      ....RIGHT TRUNCATION.....
AR(2) = 0.5 * (A(36877+M)+A(36878+M))
AR(3;21) = 0.333 * (A(36877+M;21)+A(36878+M;21)
1                                +A(36879+M;21))

```

```

AR(24) = 0.5 * (A(36898+M)+A(36899+M))
AAR(1;3840) = Q8VXPND(A(1;24),BX;A(1;3840))
A(36876+M;24) = Q8VCMPRS(A(32850+M;3840),BX;A(36876+M;24))
C
C      ....MAIN HZ LOOPS.....
D1 = A(33012+M;3678)
D2 = A(41062+M;3678) - A(4162+M;3678) + A(12321+M;3678)
1          - A(12322+M;3678)
A(33012+M;3678) = D1 + D2
C
A(32851+M;3840) = Q8VCTRL(AAL(1;3840),BW;A(32851+M;3840))
80 A(32851+M;3840) = Q8VCTRL(AAR(1;3840),BX;A(32851+M;3840))
FREE
82 CONTINUE
IF(MCALL.LE.20)GO TO 94
C
C      ....TRANSVERSE PLANE NO. 65.....
M = 63 * 36900
C
C      ....EX, EZ TRUNCATIONS.....
A(40901+M;4000) = A(36901+M;4000)
A(36901+M;4000) = A(45061+M;4000)
A(45061+M;4000) = A(4001+M;4000)
C
A(57221+M;4000) = A(53221+M;4000)
A(53221+M;4000) = A(61381+M;4000)
A(61381+M;4000) = A(20321+M;4000)
C
C      ....HX ITERATION.....
ASSIGN D1,.DYN.3839
ASSIGN D2,.DYN.3839
D1 = A(24481+M;3839)
D2 = A(12321+M;3839) - A(12161+M;3839) + A(20321+M;3839)
1          - A(57221+M;3839)
A(24481+M;3839) = D1 + D2
D4 = VABS(A(28161+M;159);D4)
BY = D4.GT.A(28481+M;159)
A(28481+M;159) = Q8VCTRL(D4,BY;A(28481+M;159))
FREE
C
C      ....HZ ITERATION.....
ASSIGN D1,.DYN.3678
ASSIGN D2,.DYN.3678
AL(2) = 0.5 * (A(36852+M)+A(36853+M))
AL(3;21) = 0.333 * (A(36852+M;21)+A(36853+M;21))
1          + A(36854+M;21)
AL(24) = 0.5 * (A(36873+M)+A(36874+M))
AAL(1;3840) = Q8VXPND(AL(1;24),BW;AAL(1;3840))
A(36851+M;24) = Q8VCMPRS(A(32852+M;3840),BW;A(36851+M;24))
AP(2) = 0.5 * (A(36877+M)+A(36878+M))
AP(3;21) = 0.333 * (A(36877+M;21)+A(36878+M;21))
1          + A(36879+M;21)

```

AR(24) = 0.5 * (A(36898+M)+A(36899+M))
AAR(1;3840) = Q8VXPND(AR(1;24),BX;AAR(1;3840))
A(36876+M;24) = Q8VCMPRS(A(32850+M;3840),BX;A(36876+M;24))
D1 = A(33012+M;3678)
D2 = A(41062+M;3678) - A(4162+M;3678) + A(12321+M;3678)

1 - A(12322+M;3678)

A(33012+M;3678) = D1 + D2

A(32851+M;3840) = Q8VCTRL(AAL(1;3840),BW;A(32851+M;3840))

A(32851+M;3840) = Q8VCTRL(AAR(1;3840),BX;A(32851+M;3840))

FREE

C

C VERT. PLANE ENVELOPE COMPUTATION....

94 ASSIGN D1,.DYN.3840

ASSIGN D2,.DYN.3840

ASSIGN BV,BBB(1;3840)

M = 32 * 36900

MZ = 65 * 36900

C

C EX ENVELOPE....

D1 = 0.5 * (A(4001+M;3840)+A(40901+M;3840))

D2 = VABS(D1;D2)

BV = D2.GT.A(MZ+1;3840)

A(MZ+1;3840) = Q8VCTRL(D2,BV;A(MZ+1;3840))

C

C EY ENVELOPE....

D2 = VABS(A(12161+M;3840);D2)

BV = D2.GT.A(MZ+4001;3840)

A(MZ+4001;3840) = Q8VCTRL(D2,BV;A(MZ+4001;3840))

C

C EZ ENVELOPE....

D1 = 0.5 * (A(20321+M;3840)+A(57221+M;3840))

D2 = VABS(D1;D2)

BV = D2.GT.A(MZ+8001;3840)

A(MZ+8001;3840) = Q8VCTRL(D2,BV;A(MZ+8001;3840))

C

C HX ENVELOPE....

D2 = VABS(A(24481+M;3840);D2)

BV = D2.GT.A(MZ+12001;3840)

A(MZ+12001;3840) = Q8VCTRL(D2,BV;A(MZ+12001;3840))

C

C HY ENVELOPE....

D1 = 0.5 * (A(28641+M;3840)+A(65541+M;3840))

D2 = VABS(D1;D2)

BV = D2.GT.A(MZ+16001;3840)

A(MZ+16001;3840) = Q8VCTRL(D2,BV;A(MZ+16001;3840))

C

C HZ ENVELOPE....

D2 = VABS(A(32851+M;3840);D2)

BV = D2.GT.A(MZ+20001;3840)

A(MZ+20001;3840) = Q8VCTRL(D2,BV;A(MZ+20001;3840))

FREE

T3 = SECOND(CP)

PRINT 150, T3

```

C
C      ....FIELD ENVELOPE PRINTOUT ROUTINE.....
DO 100 L=NHALF,NMAX,NHALF
IF(N.EQ.L)GO TO 101
100 CONTINUE
IF(N.EQ.NMAX)GO TO 101
GO TO 199
C
C      ....AT HORIZONTAL SYMMETRY PLANE.....
101 IF(N.EQ.NMAX)IPUN=1
PRINT 102, N
102 FORMAT(1H1,52X,27HEZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENVH(24321,RC,IPUN)
C
PRINT 103, N
103 FORMAT(1H1,52X,27HHX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENVH(28481,3.77E+6,IPUN)
C
PRINT 104, N
104 FORMAT(1H1,52X,27HHY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENVH(32691,3.77E+6,IPUN)
C
C      ....AT VERTICAL SYMMETRY PLANE.....
PRINT 105, N
105 FORMAT(1H1,52X,27HEX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL ENVV(1,RC,IPUN)
C
PRINT 106, N
106 FORMAT(1H1,52X,27HEY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL ENVV(4001,RC,IPUN)
C
PRINT 107, N
107 FORMAT(1H1,52X,27HEZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL ENVV(8001,RC,IPUN)
C
PRINT 108, N
108 FORMAT(1H1,52X,27HHX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL ENVV(12001,3.77E+6,IPUN)
C
PRINT 109, N
109 FORMAT(1H1,52X,27HHY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL ENVV(16001,3.77E+6,IPUN)
C
PF INT 110, N

```

```

110 FORMAT(1H1,52X,27HZ ENVELOPE FOR TIME STEP #,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)

CALL ENVV(20001,3.77E+6,IPUN)

C
199 CONTINUE
200 CONTINUE
T4 = SECOND(CP)
PRINT 150, T4
STOP
END

SUBROUTINE ENVH(LOCA,SCALE,IPUNCH)
DIMENSION A(2422500),IP(10240),NN(160)
COMMON A

C
DO 9 I=1,160
9 NN(I) = I

C
DO 1 LY=2,64
LOC = LOCA + (LY-1)*36900
LOCI = 1 + (LY-1)*160
IP(LOCI;160) = SCALE * A(LOC;160)
1 A(LOC;160) = 0.

C
IF(IPUNCH.EQ.0)GO TO 4
DO 2 LY=15,52
LOCI = 1 + (LY-1)*160
LOCII = LOCI + 158
2 WRITE(8,3) (IP(LL),LL=LOCI,LOCII)
3 FORMAT(16I5)

C
4 DO 7 LX=1,6
LXA = 5 + (LX-1)*25
LXB = LXA + 24
DO 5 LY=2,64
LYY = 66 - LY
LOCI = LXA + (LYY-1)*160
LOCII = LOCI + 24
5 PRINT 6, LYY, (IP(LL),LL=LOCI,LOCII)
6 FORMAT(1X,I2,2X,25I5)
7 PRINT 8, (NN(LL),LL=LXA,LXB)
8 FORMAT(//,4X,25I5,///)

C
RETURN
END

SUBROUTINE ENVV(LOCZ,SCALE,IPUNCH)
DIMENSION A(2422500),NN(160),IPR(25),IPP(160)
COMMON A

C
DO 8 I=1,160
8 NN(I) = I

```

```
LMN = LOCZ + 65*36900
C
IF(IPUNCH.EQ.0)GO TO 3
DO 1 LZ=1,24
LOC = LMN + (LZ-1)*160
IPP(1;159) = SCALE * A(LOC;159)
1 WRITE(8,2) (IPP(LL),LL=1,159)
2 FORMAT(16I5)
C
3 DO 6 LX=1,6
LXA = 5 + (LX-1)*25
LXB = LXA + 24
DO 4 LZ=1,24
LZZ = 25 - LZ
LOC = LMN + (LZZ-1)*160 + LXA-1
IPR(1;25) = SCALE * A(LOC;25)
4 PRINT 5, LZZ, (IPR(LL),LL=1,25)
5 FORMAT(1X,I2,2X,25I5)
6 PRINT 7, (NN(LL),LL=LXA,LXB)
7 FORMAT(1/,4X,25I5,1/)
C
A(LMN;3840) = 0.
RETURN
END
```

2.2 Problem B -- Task 1, Case 2
(Section 3.2 of Volume 1)

The following 11 pages list the computer program for the 159 x 64 x 24 cell -- 800 time step run of Problem B. The problem solved is penetration of a 19.0 cm diameter, 68.5 cm long, open-ended aluminum cylinder by a 300 MHz plane wave at broadside incidence and TM polarization.

PROGRAM FDTD(INPUT,OUTPUT,TAPE60=INPUT,TAPE8=TAPE8)

C
C RUN TASK1-- STEADY 200 MHZ PLANE WAVE IRRADIATION OF A
C 19.0 CM DIAMETER, 48.5 CM LONG, OPEN-ENDED
C ALUMINUM CYLINDER
C CASE II- TM POLARIZATION OF THE INCIDENT WAVE
C BROADSIDE INCIDENCE
C INCIDENT WAVE COMPONENTS HZ AND EX
C 159 X 64 X 24 CELL CURIC SPACE LATTICE IS USED
C UNIT CELL DIAMETER = DX = 0.5 CM = WAVELENGTH/200
C EVEN SYMMETRY AROUND LATTICE PLANE Z = 24.5*DX IS ASSUMED
C SOFT TEM WAVE SOURCE CONDITION IS USED AT PLANE Y = 3.5*DX
C SOFT LATTICE TRUNCATIONS ARE USED
C PROGRAM IS OPTIMIZED FOR THE CDC STAR-100

C
REAL MUR,MUZ
DIMENSION A(2422500),CEXR(245760),CEYB(245760),CEZB(245760),
1 DD(160),MO(24),AL(24),AR(24),CA(9),
2 CR(9),FPS(3),SIG(3), KEXB(19),KEXC(19)
COMMON A,CEXH,CEYR,CEZA
DESCRIPTOP D1,D2,D3,D4,NFD,BV,HY,A1,A2
HIT BV,RRH(13840),HY,RRY(159)
ASSIGN BV,RRH(13840)
ASSIGN BY,RRY(159)
ASSIGN D4,DD(159)
T1 = SFCOND(CP)
PRINT 150, T1
150 FORMAT(F20.5)

C
C,I. PROBLEM PARAMETERS.....
FREQ = 3.0E+8
DX = 0.005
MPP = 3
DATA FPS/1.0, 1.0, 1.0/
DATA SIG/0.0, 3.7E+7, 0.01/
NMAX = 800

C
C,CYLINDER GEOMETRY DESCRIPTION.....
DATA KEXR/19,16,14,13,12,11,10,9,8,8,7,7,7,6,6,6,6,6/
DATA KEXC/24,19,16,14,13,12,11,10,9,8,8,7,7,7,6,6,6,6/
C
C,II. BASIC AND DERIVED CONSTANTS.....
PI = 3.14159265
MUZ = 4.0 * PI * 1.0E-7
EPSZ = 1.0E-12
DT = DX / 6.0E+8
NMA, F = 0.5 / FREQ / DT
R = DT / 2.0 / EPSZ
RA = DT**2 / DX**2 / MUZ / EPSZ
RRI = DT / DX / MUZ
RC = 1.0E+4 / RA / 377.0
RD = 2.0 * PI * FREQ * DT
IPLIN = 0

```

C
CA(1:9) = 0.
CB(1:9) = 0.
DO 1 KK=1,24
1 MQ(KK) = 160 * (KK-1)
DO 2 I=1,MPR
EAF = P * SIG(I) / FPS(I)
CA(I) = (1.0-EAF) / (1.0+EAF)
2 CB(I) = RA / EPS(I) / (1.0+EAF)

C
C      ....III. LOAD VECTOR A.....
C      .....ZERO INITIAL FIELDS.....
DO 3 I=1,65
IDEL = (I-1) * 36900
3 A(IDFL+1:36900) = 0.
A(2398501:24000) = 0.

C
C      .....TYPE OF MEDIUM.....
C      .....ANISOTROPIC LOSSY AIR.....
DO 4 I=1,64
IDEL = (I-1) * 36900
A(IDEL+1:3840) = 1.
A(IDEL+8161:3840) = 3.
4 A(IDEL+16321:3840) = 3.

C
C      .....BROADSIDE CIRCULAR CYLINDER.....
DO 14 I=15,33
IDEL = (I-1) * 36900
IDEM = I*36900
KB = KEXB(I-14)
KC = KEXC(I-14)
DO 7 K=KB,KC
7 A(IDFL+11+(K-1)*160:137) = 2.
KD = KC + 1
DO 8 K=KD,24
8 A(IDEL+11+(K-1)*160:137) = 3.

C
A(IDEM+8171+(KB-1)*160:138) = 2.
DO 10 K=KB,24
10 A(IDEM+8308+(K-1)*160) = 2.

C
KB = KEXB(I-14) + 1
IF(KB.GT.KC) GO TO 9
DO 12 K=KB,KC
12 A(IDFL+16331+(K-1)*160:138) = 2.
9 DO 13 K=KB,24
13 A(IDFL+16468+(K-1)*160) = 2.

C
IA = 67 - I
IDEA = (IA-1) * 36900
A(IDFLA+1:3840) = A(IDFL+1:3840)
A(IDELA+16321:3840) = A(IDEL+16321:3840)
14 A(IDFLA+8161:3840) = A(IDEM+8161:3840)

```

```

C
C      .....MEDIA COEFFICIENTS.....
ASSIGN A1,,DYN,3840
ASSIGN A2,,DYN,3840
ASSIGN NFD,,DYN,3840
A1 = 0.
A2 = 0.
DO 23 I=1,64
IDEL = (I-1) * 36900
IDEM = (I=1) * 3840
C
NFD = A(IDEL+1:3840)
DO 20 JJ=1,MPR
BV = NFD,EQ,JJ
A1 = Q8VCTRL(CA(JJ),RV$A1)
20 A2 = Q8VCTRL(CB(JJ),RV$A2)
A(IDEL+1:3840) = A1
CEXB(IDEM+1:3840) = A2
C
NFD = A(IDEL+8161:3840)
DO 21 JJ=1,MPR
BV = NFD,EQ,JJ
A1 = Q8VCTRL(CA(JJ),RV$A1)
21 A2 = Q8VCTRL(CH(JJ),RV$A2)
A(IDEL+8161:3840) = A1
CEYB(IDEM+1:3840) = A2
C
NFD = A(IDEL+16321:3840)
DO 22 JJ=1,MPR
BV = NFD,EQ,JJ
A1 = Q8VCTRL(CA(JJ),RV$A1)
22 A2 = Q8VCTRL(CH(JJ),RV$A2)
A(IDEL+16321:3840) = A1
23 CEZB(IDEM+1:3840) = A2
FREE
A(8161:3840) = 0.
C
T2 = SECOND(CP)
PRINT 150,T2
C
C      .....IV. TIME-STEPPING LOOP.....
DO 200 N=1,NMAX
TERM = SIN(FLOAT(N)*RD)
MCALL = 3 + IFIX(FLOAT(N)/6.0)
IF (MCAL.L.GT.21) MCALL=21
C
C      .....TRANSVERSE PLANE NO. 1.....
C      ....HX, HZ TRUNCATIONS.....
A(4001:4000) = A(8161:4000)
A(8151:4000) = A(4090:4000)
A(20321:4000) = A(28641:4000)
A(28641:4000) = A(57221:4000)
C

```

CHY ITERATION.....

ASSIGN D1,.DYN.3679
 ASSIGN D2,.DYN.3679

A(12161) = 0.5 * (A(16161)+A(16162))
 A(12162+157) = 0.333 * (A(16161+157)+A(16162+157))
 +A(16163+157))

1
 A(12319) = 0.5 * (A(16318)+A(16319))
 A(16318+159) = A(12321+159)

D1 = A(12321+3679)
 D2 = A(24641+3679) - A(24481+3679) + A(33011+3679)
 - A(33012+3679)

1
 A(12321+3679) = D1 - D2
 FREE

C

CTRANSVERSE PLANES 2-64.....

DO 82 JY=1,MCALL
 JDEL = (JY-1) * 110700
 JDEM = (JY-1) * 11520

C

.....HX ITERATION.....

ASSIGN D1,.DYN.367H
 ASSIGN D2,.DYN.367H

C

DO 30 MA=1,3
 M = JDEL + 36900*(MA-1)

C

.....SOFT LATTICE TRUNCATION.....

A(40902+M) = 0.5 * (A(44902+M)+A(44903+M))
 A(40903+M+156) = 0.333 * (A(44902+M+156)+A(44903+M+156))
 +A(44904+M+156))

1
 A(41059+M) = 0.5 * (A(45058+M)+A(45059+M))
 A(44902+M+158) = A(41062+M+158)

C

.....MAIN HX LOOPS.....

D1 = A(41062+M+3678)
 D2 = A(69912+M+3678) - A(33012+M+3678) + A(65542+M+3678)
 - A(65702+M+3678)

1
 30 A(41062+M+3678) = D1 - D2
 FREE

C

.....HY ITERATION.....

ASSIGN D1,.DYN.3679
 ASSIGN D2,.DYN.3679

C

DO 40 MA=1,3
 M = JDEL + 36900*(MA-1)

C

.....SOFT LATTICE TRUNCATION.....

A(49061+M) = 0.5 * (A(53061+M)+A(53062+M))
 A(49062+M+157) = 0.333 * (A(53061+M+157)+A(53062+M+157))
 +A(53063+M+157))

1
 A(49219+M) = 0.5 * (A(53218+M)+A(53219+M))
 A(53061+M+159) = A(49221+M+154)

C

CMAIN HY LOOPS.....

D1 = A(49221+M\$3679)
D2 = A(61541+M\$3679) - A(61381+M\$3679) + A(69911+M\$3679)
1 - A(69912+M\$3679)

40 A(49221+M\$3679) = D1 - D2
FREE

C

CHZ ITERATION.....

ASSIGN D1..DYN.3839
ASSIGN D2..DYN.3839

C

DO 50 MA=1,3
M = JDFL + 36900*(MA-1)

C

CMAIN HZ LOOPS.....

D1 = A(57221+M\$3839)
D2 = A(65542+M\$3839) - A(65541+M\$3839) + A(24481+M\$3839)
1 - A(61381+M\$3839)

A(57221+M\$3839) = D1 - D2

C

CHZ SOFT TFM WAVE SOURCE CONDITION.....

IF(JY.GE.2.OR.MA.LE.2)GO TO 47
A(131021+3839) = TFRM + A(131021+3839)

C

CHZ HOR. PLANE ENVELOPE COMPUTATION.....

47 D4 = VABS(A(60401+M\$159);D4)
RY = D4.GT.A(61221+M\$159)
50 A(61221+M\$159) = QAVCTRL(D4,RY;A(61221+M\$159))

C

CEX ITERATION.....

ASSIGN D3..DYN.3839

C

DO 60 MA=1,3
M = JDFL + 36900*(MA-1)
MM = JDEM + 3840*(MA-1)

C

CMAIN EX LOOPS.....

D1 = A(24481+M\$3839) * A(1+M\$3839)
D2 = A(12321+M\$3839) - A(12161+M\$3839) + A(20321+M\$3839)
1 - A(57221+M\$3839)

D3 = CFXR(1+MM\$3839) * D2
A(24481+M\$3839) = D1 - D3

C

CFX HOR. PLANE ENVELOPE COMPUTATION.....

D4 = VAHS(A(25161+M\$159);D4)
RY = D4.GT.A(28481+M\$159)
60 A(28481+M\$159) = QAVCTRL(D4,RY;A(28481+M\$159))
FREE

C

CFY ITERATION.....

ASSIGN D1..DYN.3838
ASSIGN D2..DYN.3839

ASSIGN D3..DYN.3838

C

DO 70 MA=1,3

M = JDEL + 36900*(MA-1)

MM = JDEM + 3840*(MA-1)

C

CSOFT LATTICE TRUNCATIONS....

CLEFT TRUNCATION....

AL(1) = 0.5 * (A(69541+M)+A(69542+M))

AL(2:22) = 0.333 * (A(69541+M:22)+A(69542+M:22))

1 AL(24) = 0.333 * (A(69563+M)+2.0*A(69564+M))

C

CRIGHT TRUNCATION....

AR(1) = 0.5 * (A(69566+M)+A(69567+M))

AR(2:22) = 0.333 * (A(69566+M:22)+A(69567+M:22))

1 AR(24) = 0.333 * (A(69588+M)+2.0*A(69589+M))

C

DO 61 KK=1,24

MLE = M + KK

MRI = M + MQ(KK)

A(69540+MLE) = A(65542+MRI)

61 A(69565+MLE) = A(65699+MRI)

C

CMAIN EY LOOPS....

D1 = A(65542+M:3838) * A(45062+M:3838)

D2 = A(57222+M:3838) - A(57221+M:3838) + A(40902+M:3838) - A(41062+M:3838)

1 D3 = CEYB(3842+MM:3838) * D2

A(65542+M:3838) = D1 - D3

C

DO 69 KK=1,24

MLE = M + MQ(KK)

A(65541+MLE) = AL(KK)

69 A(65700+MLE) = AR(KK)

C

CEY HOR. PLANE ENVELOPE COMPUTATION....

D4 = VABS(A(69221+M:159);D4)

BY = D4.GT.A(69591+M:159)

70 A(69591+M:159) = Q8VCTRL(D4,BY;A(69591+M:159))

FREE

C

CEZ ITERATION....

ASSIGN D1..DYN.3678

ASSIGN D2..DYN.3679

ASSIGN D3..DYN.3678

C

DO 80 MA=1,3

M = JDEL + 36900*(MA-1)

MM = JDEM + 3840*(MA-1)

C

CSOFT LATTICE TRUNCATIONS....

CLEFT TRUNCATION.....

$$AL(2) = 0.5 * (A(36852+M)+A(36853+M))$$

$$AL(3821) = 0.333 * (A(36852+M21)+A(36853+M21))$$

$$+ A(36854+M21))$$

$$AL(24) = 0.5 * (A(36873+M)+A(36874+M))$$

C

CRIGHT TRUNCATION.....

$$AR(2) = 0.5 * (A(36877+M)+A(36878+M))$$

$$AR(3821) = 0.333 * (A(36877+M21)+A(36878+M21))$$

$$+ A(36879+M21))$$

$$AR(24) = 0.5 * (A(36898+M)+A(36899+M))$$

C

DO 71 KK=1,24

$$MLE = M + KK$$

$$MRI = M + MQ(KK)$$

$$A(36850+MLE) = A(32852+MRI)$$

$$71 A(36875+MLE) = A(33009+MRI)$$

C

CMAIN EZ LOOPS.....

$$D1 = A(33012+M3678) * A(16482+M3678)$$

$$D2 = A(41062+M3678) - A(4162+M3678) + A(12321+M3678)$$

$$- A(12322+M3678)$$

$$D3 = CFZB(162+MM3678) * D2$$

$$A(33012+M3678) = D1 - D3$$

C

DO 80 KK=1,24

$$MLE = M + MQ(KK)$$

$$A(32851+MLE) = AL(KK)$$

$$80 A(33010+MLE) = AR(KK)$$

FREEF

82 CONTINUE

IF(MCALL,LF,20) GO TO 94

C

CTRANSVERSE PLANE NO. 65.....

$$M = 63 * 36900$$

C

CHX, HZ TRUNCATIONS.....

$$A(40901+M4000) = A(36901+M4000)$$

$$A(36901+M4000) = A(45061+M4000)$$

$$A(45061+M4000) = A(4001+M4000)$$

C

$$A(57221+M4000) = A(53221+M4000)$$

$$A(53221+M4000) = A(513H1+M4000)$$

$$A(513H1+M4000) = A(20321+M4000)$$

C

CEX ITERATION.....

ASSIGN D1..,DYN,3839

ASSIGN D2..,DYN,3839

ASSIGN D3..,DYN,3839

$$D1 = A(24481+M3839) * CA(1)$$

$$D2 = A(12321+M3839) - A(12161+M3839) + A(20321+M3839)$$

$$- A(57221+M3839)$$

$$1$$

$$D3 = CR(1) * D2$$

$A(244A1+M\$3839) = D1 - D3$
 $D4 = VARS(A(28161+M\$159)\$D4)$
 $RY = D4, GT, A(28481+M\$159)$
 $A(284A1+M\$159) = Q8VCTRL(D4, RY\$A(28481+M\$159))$
 $FREE$

C

C,EZ ITERATION.....

ASSIGN D1..,DYN,3678
 ASSIGN D2..,DYN,3678
 ASSIGN D3..,DYN,3678
 $AL(2) = 0.5 * (A(36452+M)+A(36453+M))$
 $AL(3\$21) = 0.333 * (A(36852+M\$21)+A(36853+M\$21))$
 $+ A(36854+M\$21))$
 1
 $AL(24) = 0.5 * (A(36873+M)+A(36874+M))$
 $AR(2) = 0.5 * (A(36877+M)+A(36878+M))$
 $AR(3\$21) = 0.333 * (A(36877+M\$21)+A(36878+M\$21))$
 $+ A(36879+M\$21))$
 1

AR(24) = 0.5 * (A(36898+M)+A(36899+M))

DO 91 KK=1,24

MLE = M + KK

MRI = M + MQ(KK)

A(36850+MLE) = A(32852+MRI)

91 A(36875+MLE) = A(33009+MRI)

D1 = A(33012+M\\$3678) * CA(3)

D2 = A(41062+M\\$3678) - A(4162+M\\$3678) + A(12321+M\\$3678)
 - A(12322+M\\$3678)

1

D3 = CR(3) * D2

A(33012+M\\$3678) = D1 - D3

DO 92 KK=1,24

MLE = M + MQ(KK)

A(32851+MLE) = AL(KK)

92 A(33010+MLE) = AR(KK)

FREE

C

C,VERT. PLANE ENVELOPE COMPUTATION.....

94 ASSIGN D1..,DYN,3840

ASSIGN D2..,DYN,3840

M = 32 * 36900

MZ = 65 * 36900

C

C,HX ENVELOPE.....

D2 = VABS(A(40901+M\\$3840)\\$D2)

BV = D2, GT, A(MZ+1\\$3840)

A(MZ+1\\$3840) = Q8VCTRL(D2, BV\\$A(MZ+1\\$3840))

C

C,HY ENVELOPE.....

D1 = 0.5 * (A(12161+M\\$3840)+A(49061+M\\$3840))

D2 = VABS(D1\\$D2)

BV = D2, GT, A(MZ+4001;3840)

A(MZ+4001;3840) = Q8VCTRL(D2, BV\\$A(MZ+4001;3840))

C

C,HZ ENVELOPE.....

D2 = VARS(A(57221+M\\$3840)\\$D2)

RV = D2.GT.A(MZ+8001;3840)
A(MZ+8001;3840) = ORVCTRL(D2,BV+A(MZ+8001;3840))

C

.....EX ENVELOPE.....

D1 = 0.5 * (A(24481+M\$3840)+A(61381+M\$3840))

D2 = VABS(D1:D2)

BV = D2.GT.A(MZ+12001;3840)

A(MZ+12001;3840) = ORVCTRL(D2,BV+A(MZ+12001;3840))

C

.....EY ENVELOPE.....

D2 = VARS(A(65541+M\$3840):D2)

BV = D2.GT.A(MZ+16001;3840)

A(MZ+16001;3840) = ORVCTRL(D2,BV+A(MZ+16001;3840))

C

.....EZ ENVELOPE.....

D1 = 0.5 * (A(32851+M\$3840)+A(69751+M\$3840))

D2 = VARS(D1:D2)

BV = D2.GT.A(MZ+20001;3840)

A(MZ+20001;3840) = ORVCTRL(D2,BV+A(MZ+20001;3840))

FREE

T3 = SFCOND(CP)

PPINT 150, T3

C

.....FIELD ENVELOPE PRINTOUT ROUTINE.....

DO 100 L=NHALF,NMAX,NHALF

IF(N.EQ.L)GO TO 101

100 CONTINUE

IF(N.EQ.NMAX)GO TO 101

GO TO 199

C

.....AT HORIZONTAL SYMMETRY PLANE.....

101 IF(N.EQ.NMAX)IPUN=1

PRINT 102, N

102 FORMAT(1H1.52X,27HZ ENVELOPE FOR TIME STEP =,15,

1 //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/) CALL FNVH(24321,10000,0,IPUN)

C

PRINT 103, N

103 FORMAT(1H1.52X,27HZ ENVELOPE FOR TIME STEP =,15,

1 //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/) CALL FNVH(2R4R1,RC,IPUN)

C

PRINT 104, N

104 FORMAT(1H1.52X,27HZ ENVELOPE FOR TIME STEP =,15,

1 //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/) CALL FNVH(32691,RC,IPUN)

C

.....AT VERTICAL SYMMETRY PLANE.....

PRINT 105, N

105 FORMAT(1H1.52X,27HZ ENVELOPE FOR TIME STEP =,15,

1 //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/) CALL ENVV(1,10000,0,IPUN)

C

```

PRINT 106, N
106 FORMAT(1H1,52X,27HHY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL FNVV(4001,10000,0,IPUN)

C
PRINT 107, N
107 FORMAT(1H1,52X,27HHY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL FNVV(8001,10000,0,IPUN)

C
PRINT 108, N
108 FORMAT(1H1,52X,27HHE ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL ENVV(12001,PC,TPUN)

C
PRINT 109, N
109 FORMAT(1H1,52X,27HFY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL FNVV(16001,RC,TPUN)

C
PRINT 110, N
110 FORMAT(1H1,52X,27HFZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE Y = 32.5*DX,/,2X,1HK,/)
CALL FNVV(20001,RC,IPUN)

C
199 CONTINUE
200 CONTINUE
T4 = SECOND(CH)
PRINT 150, T4
STOP
END

SUBROUTINE FNVH(LOCA,SCALE,IPUNCH)
DIMENSION A(2422500),IP(10240)*NN(160)
COMMON A
DO 9 I=1,160
  9 NN(I) = I
C
DO 1 LY=2,64
  LOC = LOCA + (LY-1)*36900
  LOCI = I + (LY-1)*160
  IP(LOCI:160) = SCALE * A(LOC:160)
  1 A(LOC:160) = 0.

C
IF(IPUNCH.EQ.0)GO TO 4
DO 2 LY=15,52
  LOCI = I + (LY-1)*160
  LOCI = LOCI + 160
  2 WRITE(P,3) (IP(LL),LL=LOCI,LOCII)
  3 FORMAT(16I5)
C
  4 DO 7 LX=1,6
    LXA = 5 + (LX-1)*25

```

```

LXB = LXA + 24
DO 5 LY=2,64
LYY = 66 - LY
LOCI = LXA + (LYY-1)*160
LOCII = LOCI + 24
5 PRINT 6, LYY, (IP(LL),LL=LOCI,LOCII)
6 FORMAT(1X,I2,2X,25I5)
7 PRINT 8, (NN(LL),LL=LXA,LXB)
8 FORMAT(1/,4X,25I5,1//)
C
RETURN
END

SUBROUTINE FNVV(LOC7,SCALE,IPUNCH)
DIMENSION A(24*2500),NN(160),IPR(25),IPP(160)
COMMON A
C
DO 8 I=1,160
8 NN(I) = I
LMN = LOC7 + 65*36400
C
IF (IPUNCH.EQ.0) GO TO 3
DO 1 I7=1,24
LOC = LMN + (I7-1)*160
IPP(1:159) = SCALF * A(LOC:159)
1 WRITE(8,2) (IPP(LL),LL=1,159)
2 FORMAT(16I5)
C
3 DO 6 LX=1,6
LXA = 5 + (LX-1)*25
LXB = LXA + 24
DO 4 LZ=1,24
LZZ = 25 - LZ
LOC = LMN + (LZZ-1)*160 + LXA-1
IPR(1:25) = SCALF * A(LOC:25)
4 PRINT 5, LZZ, (IPR(LL),LL=1,25)
5 FORMAT(1X,I2,2X,25I5)
6 PRINT 7, (NN(LL),LL=LXA,LXB)
7 FORMAT(1/,4X,25I5,1//)
C
A(LMN:36400) = 0,
RETURN
END

```

2.3 Problem C -- Task 2, Case 1
(Section 4.1 of Volume 1)

The following 10 pages list the computer program for the 24 x 100 x 24 cell -- 1800 time step run of Problem C. The problem solved is penetration of a 12.8 cm diameter, 28 cm long, missile guidance section by a 300 MHz plane wave at axial incidence, for the case of the interior dielectric components modeled.

```

PROGRAM FDTD (INPUT,OUTPUT,TAPF50=INPUT,TAPFR=TAPE8)

C
C RUN TASK2-- STEADY 300 MHZ PLANE WAVE IRRADIATION OF A
C 12.8 CM DIAMETER MISSILE GUIDANCE SECTION
C CASE T- INTERIOR DIELECTRIC COMPONENTS MODELED
C AXIAL INCIDENCE
C INCIDENT WAVE COMPONENTS EZ AND HX
C 24 X 100 X 24 CELL CUBIC SPACE LATTICE IS USED
C UNIT CELL DIAMETER = DX = 0.33 CM = WAVELENGTH/300
C EVEN SYMMETRY ABOUT LATTICE PLANES X = 24.5*DX AND
C Z = 24.0*DX IS ASSUMED
C SOFT TEM WAVE SOURCE CONDITION IS USED AT PLANE Y = 3.0*DX
C SOFT LATTICE TRUNCATIONS ARE USED
C PROGRAM IS OPTIMIZED FOR THE CDC STAR-100
C

REAL MUZ, MIZ
DIMENSION A(499536),CFXR(60000),CFYR(60000),CFZR(60000),
I      Z(5936),AAA(600),AA(25),DD(24),DE(24),CA(9),
?      CR(9),EPS(6),SIG(6)
COMMON A,CFXR,CFYR,CFZR
NFSRTOPI D1,D2,D3,D4,D5,NFU,A1,A2,HV,BW,BX,RY
HIT RV,RRP(600),RW,RRW(600),RX,RRX(600),RY,RRY(24)
ASSIGN PV,PRP(1:600)
ASSIGN PW,HPW(1:600)
ASSIGN RX,PRX(1:600)
ASSIGN RY,PRY(1:24)
ASSIGN D4,DD(1:24)
ASSIGN D5,DE(1:24)
T1 = SECOND(CP)
PPINT 150, T1
150 FORMAT (F20.5)

C
C .....I. PROBLEM PARAMETERS.....
FREQ = 3.0F+8
DX = 0.01/3.0
MPP = 6
DATA EPS/ 1.0,    1.0,    1.0,    5.5,    4.5,    5.3 /
DATA SIG/ 0.0,    3.7F+7,  0.025,  0.0024, 0.0008, 0.0 /
NMAX = 1800
NMAX = 1800

C
C .....II. BASIC AND DERIVED CONSTANTS.....
PI = 3.14159265
MUZ = 4.0 * PI * 1.0F-7
EPS7 = 8.454F-12
DT = DX / 6.0F+8
NMATF = 0.5 / FREQ / DT
R = DT / 2.0 / EPS7
RB = DT**2 / DX**2 / MUZ / EPSZ
RH = DT / DX / MUZ
RC = 1.0F+4 / RH
RF = 2.0 * PI * FREQ * DT
IPUN = 0

```

```

C
CA(1:9) = 0.
CP(1:9) = 0.
RW = QAVMK0(1,25:RW)
RX = QAVMK7(24,25:RX)
DO 2 J=1,MPP
FAF = R * SIG(I) / FPS(I)
CA(I) = (1.0-FAF) / (1.0+FAF)
2 CP(I) = RA / FPS(I) / (1.0+FAF)

C
C      ....ITI. LOAD VECTOR R.....
C      ....ZERO INITIAL FIELDS.....
Z(1:5936) = 0.
A(1:5936) = 0.
A(5936:1:5936) = 0.

C
C      ....TYPE OF MEDIUM.....
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
4 FORMAT (7SF1.0)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
DO 5 J=2,6
JDEL = (J-1) * 5936
5 A(JDEL+1:5936) = Z(1:5936)

C
DO 55 J=7,14
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
JDEL = (J-1) * 5936
55 A(JDEL+1:5936) = Z(1:5936)

C
DO 6 JA=15,71,7
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
JDEL = (JA-1) * 5936
A(JDEL+1:5936) = Z(1:5936)
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
DO 6 JP=1,6
JDEL = (JA+JP-1) * 5936
6 A(JDEL+1:5936) = Z(1:5936)
DO 7 J=93,100
JDEL = (J-1) * 5936
7 A(JDEL+1:5936) = Z(1:5936)

C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
DO 8 J=75,77
JDEL = (J-1) * 5936
8 A(JDEL+1:5936) = Z(1:5936)

```

```

C
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
J = 78
JDFL = (J-1) * 5936
A(JDFL+1:5936) = Z(1:5936)

C
READ(60,4,END=201,FRR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
J = 79
JDFL = (J-1) * 5936
A(JDFL+1:5936) = Z(1:5936)

C
READ(60,4,END=201,FRR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
DO 9 J=80,84
JDFL = (J-1) * 5936
9 A(JDFL+1:5936) = Z(1:5936)

C
READ(60,4,END=201,FRR=201) (Z(I),I=1301,1900)
J = 85
JDFL = (J-1) * 5936
A(JDFL+1:5936) = Z(1:5936)

C
READ(60,4,END=201,FRR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
DO 10 J=86,87
JDFL = (J-1) * 5936
10 A(JDFL+1:5936) = Z(1:5936)

C
READ(60,4,END=201,FRR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
DO 11 J=88,91
JDFL = (J-1) * 5936
11 A(JDFL+1:5936) = Z(1:5936)

C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,FRR=201) (Z(I),I=2601,3200)
J = 92
JDFL = (J-1) * 5936
A(JDFL+1:5936) = Z(1:5936)

C
.....MEDIA COEFFICIENTS.....
ASSIGN A1..,DYN,600
ASSIGN A2..,DYN,600
ASSIGN NFM..,DYN,600
A1 = 0.
A2 = 0.
DO 23 J=2,100
JDFL = (J-1) * 5936
JDFM = (J-1) * 600

```

```

C
      NFD = A(JDFL+1:600)
      DO 20 JJ=1,MPH
      RV = NFD,F0,JJ
      A1 = ORVCTFL(CA(JJ),RV;A1)
20   A2 = ORVCTFL(CH(JJ),RV;A2)
      A(JDFL+1:600) = A1
      CFXR(JDFM+1:600) = A2

C
      NFD = A(JDFL+1301:600)
      DO 21 JJ=1,MPH
      RV = NFD,F0,JJ
      A1 = ORVCTFL(CA(JJ),RV;A1)
21   A2 = ORVCTFL(CH(JJ),RV;A2)
      A(JDEL+1301:600) = A1
      CEYR(JDEM+1:600) = A2

C
      NFD = A(JDFL+2601:600)
      DO 22 JJ=1,MPH
      RV = NFD,F0,JJ
      A1 = ORVCTFL(CA(JJ),RV;A1)
22   A2 = ORVCTFL(CH(JJ),RV;A2)
      A(JDEL+2601:600) = A1
23   CFZR(JDEM+1:600) = A2
      FREE

C
      T2 = SFCONT(CH)
      PRINT 150, T2

C
      .....IV. TIME-STEPPING LCP.....
      DO 200 N=1,NMAX
      TERM = SIN(FLOAT(N)*PI) * RH
      MCALL = 3 + IFIX(FLOAT(N)/E.0)
      IF(MCALL.GT.33)MCALL=33

C
      .....TRANSVERSE PLANF NO. 1.....
      .....FX, EZ TRUNCATIONS.....
      A(626:625) = A(1:625)
      A(1:625) = A(6562:625)
      A(3226:625) = A(2601:625)
      A(2601:625) = A(9162:625)

C
      .....FY ITERATION.....
      ASSIGN D1,.DYN.574
      ASSIGN D2,.DYN.574
      ASSIGN D3,.DYN.574
      A(1926) = 0.5 * (A(2551)+A(2552))
      A(1927:22) = 0.333 * (A(2551:22)+A(2552:22)+A(2553:22))
      A(1949) = 0.333 * (A(2573) + 2.0*A(2574))
      A(2551:24) = A(1951:24)
      D1 = CA(3) * A(1951:574)
      D2 = A(3926:574) - A(3901:574) + A(5276:574) - A(5277:574)
      D3 = CR(3) * D2

```

```

A(195)+574) = D1 + D3
FRFF

C      .....TRANSVERSE PLANES 2 - 100.....
DO R2 JY=1,MCALL
JDFL = (JY-1) * 17800
JDFM = (JY-1) * 1800

C      .....FX ITERATION.....
ASSIGN D1,,DYN,573
ASSIGN D2,,DYN,573
ASSIGN D3,,DYN,573

C      DO 30 MA=1,3
M = JDFL + 5036*(MA-1)
MM = JDFM + 600*(MA-1)

C      .....SOFT LATTICE TRUNCATION.....
A(6563+M) = 0.5 * (A(718A+M)+A(7180+M))
A(6564+M;21) = 0.333 * (A(718F+M;21)+A(7189+M;21)
                     +A(7190+M;21))
A(6585+M) = 0.5 * (A(7209+M)+A(7210+M))
A(718P+M;23) = A(6588+M;23)

C      .....MAIN FX LOOPS.....
D1 = A(5963+M;573) * A(658F+M;573)
D2 = A(11213+M;573)-A(5277+M;573)+A(10513+M;573)
     -A(10538+M;573)
D3 = CFXH(627+MM;573) * D2
30 A(6588+M;573) = D1 + D3
FRFF

C      .....FY ITERATION.....
ASSIGN D1,,DYN,574
ASSIGN D2,,DYN,574
ASSIGN D3,,DYN,574

C      DO 40 MA=1,3
M = JDFL + 5036*(MA-1)
MM = JDFM + 600*(MA-1)

C      .....SOFT LATTICE TRUNCATION.....
A(7862+M) = 0.5 * (A(R4R7+M)+A(H4RR+M))
A(7863+M;22) = 0.333 * (A(H4R7+M;22)+A(P4RH+M;22)
                     +A(H4R9+M;22))
A(7885+M) = 0.333 * (A(H509+M) + 2.0*A(H510+M))
A(F4R7+M;24) = A(7887+M;24)

C      .....MAIN FY LOOPS.....
D1 = A(72F2+M;574) * A(7RH7+M;574)
D2 = A(9RF2+M;574)-A(9R37+M;574)+A(11212+M;574)
     -A(11213+M;574)
D3 = CFYR(626+MM;574) * D2

```

```

A(7887+M$574) = D1 + D3
C
C      .....FY ENVELOPE COMPUTATION.....
D4 = QAVCMPRS(A(7861+M$600),RY*D4)
D5 = VARS(D4*D5)
RY = D5.GT.A(8512+M$24)
40 A(8512+M$24) = Q8VCTRL(D5,RY*A(8512+M$24))
      FFREE
C
C      .....FZ ITERATION.....
ASSIGN D1..,DYN,599
ASSIGN D2..,DYN,599
ASSIGN D3..,DYN,599
C
DO 50 MA=1,3
M = JDFL + 5936*(MA-1)
MM = JDEM + 600*(MA-1)
C
C      .....MAIN FZ LOOPS.....
D1 = A(8537+M$599) * A(9162+M$599)
D2 = A(10513+M$599)-A(10512+M$599)+A(3901+M$599)
      -A(9837+M$599)
1   D3 = CFZE(601+MM$599) * D2
      A(9162+M$599) = D1 + D3
C
C      .....FZ SOFT TEM WAVE SOURCE CONDITION.....
IF(JY,GF,2,0R,MA,LE,2)GO TO 47
      A(21034$599) = TERM + A(21034$599)
C
C      .....FZ ENVELOPE COMPUTATION.....
47 D4 = VARS(A(9737+M$24)*D4)
RY = D4.GT.A(9787+M$24)
      A(9787+M$24) = Q8VCTRL(D4,RY*A(9787+M$24))
D4 = QAVCMPRS(A(9161+M$600),RY*D4)
D5 = VARS(D4*D5)
RY = D5.GT.A(9812+M$24)
50 A(9812+M$24) = Q8VCTRL(D5,RY*A(9812+M$24))
C
C      .....HX ITERATION.....
DO 60 MA=1,3
M = JDFL + 5936*(MA-1)
C
C      .....MAIN HX LOOPS.....
D1 = A(3901+M$599)
D2 = A(1951+M$599)-A(1926+M$599)+A(3226+M$599)
      -A(9162+M$599)
1   A(3901+M$599) = D1 + D2
C
C      .....HX ENVELOPE COMPUTATION.....
D4 = VARS(A(4475+M$24)*D4)
RY = D4.GT.A(4526+M$24)
      A(4526+M$24) = Q8VCTRL(D4,RY*A(4526+M$24))
D4 = QAVCMPRS(A(3900+M$600),RY*D4)

```

```

D5 = VARS(D4&U5)
HY = D5.GT.A(4551+M$24)
60 A(4551+M$24) = QAVCTPL(D5,RY+A(4551+M$24))
FFFE

C
C      .....HY ITERATION.....
ASSIGN D1,.DYN.598
ASSIGN D2,.DYN.598
C
DO 70 MA=1,3
M = JDFL + 5936*(MA-1)
C
C      .....SOFT LATTICE TRUNCATION.....
AA(1) = 0.5 * (A(11137+M)+A(11138+M))
AA(2:22) = 0.333 * (A(11137+M:22)+A(11138+M$22)
           +A(11139+M$22))
1 AA(24) = 0.333 * (A(11159+M) + 2.0*A(11160+M))
AAA(1:600) = QAVXPNL(AA(1:24),RW$AAA(1:600))
A(11137+M$24) = QAVCMPRS(A(10513+M$600),RW$A(11137+M$24))
C
C      .....MAIN HY LOOPS.....
D1 = A(10513+M$598)
D2 = A(9162+M$598)-A(9162+M$548)+A(6563+M$598)
     -A(6588+M$598)
1 A(10513+M$598) = D1 + D2
C
A(10512+M$600) = QAVCTRL(AAA(1:600),RW$A(10512+M$600))
A(10512+M$600) = QAVCTRL(0.0,RW$A(10512+M$600))
C
C      .....HY ENVELOPE COMPUTATION.....
D4 = VARS(A(11087+M$24):D4)
RY = D4.GT.A(11162+M$24)
70 A(11162+M$24) = QAVCTRL(D4,RY+A(11162+M$24))
FFFE

C
C      .....HZ ITERATION.....
ASSIGN D1,.DYN.573
ASSIGN D2,.DYN.573
C
DO 80 MA=1,3
M = JDFL + 5936*(MA-1)
C
C      .....SOFT LATTICE TRUNCATION.....
AA(2) = 0.5 * (A(5877+M)+A(5878+M))
AA(3:21) = 0.333 * (A(5877+M$21)+A(5878+M$21)
           +A(5879+M$21))
1 AA(24) = 0.5 * (A(5898+M) + A(5899+M))
AAA(1:600) = QAVXPNL(AA(1:24),RW$AAA(1:600))
A(5876+M$24) = QAVCMPRS(A(5252+M$600),RW$A(5876+M$24))
C
C      .....MAIN HZ LOOPS.....
D1 = A(5277+M$573)

```

```

D2 = A(658F+M$573)-A(652+M$573)+A(1451+M$573)
1                               -A(1952+M$573)
A(5277+M$573) = D1 + D2
C
A(5251+M$600) = ORVCTRL(AAA(1$600),RW8A(5251+M$600))
80 A(5251+M$600) = ORVCTRL(0.0,0X8A(5251+M$600))
FREE
82 CONTINUE
IF(MCALL,LF,82) GO TO 94
C
C       .....TRANSVERSE PLANE NO. 101.....
N = 99 * 5E36
C
C       .....FX, FZ TRUNCATIONS.....
A(6562+M$625) = A(5937+M$625)
A(5937+M$625) = A(7237+M$625)
A(7237+M$625) = A(426+M$625)
A(9162+M$625) = A(8537+M$625)
A(8537+M$625) = A(4837+M$625)
A(4837+M$625) = A(3226+M$625)
C
C       .....HX ITERATION.....
ASSIGN D1,,DYN,549
ASSIGN D2,,DYN,599
D1 = A(3901+M$599)
D2 = A(1951+M$599)-A(1926+M$599)+A(3226+M$599)
1                               -A(9162+M$599)
A(3901+M$599) = D1 + D2
D4 = VARS(A(4476+M$24);D4)
HY = D4.GT.A(4526+M$24)
A(4526+M$24) = ORVCTRL(D4,HY;A(4526+M$24))
D4 = ORVCMPRS(A(3900+M$600),HX;D4)
D5 = VARS(D4;D5)
HY = D5.GT.A(4551+M$24)
A(4551+M$24) = ORVCTRL(D5,HY;A(4551+M$24))
FREE
C
C       .....HZ ITERATION.....
ASSIGN D1,,DYN,573
ASSIGN D2,,DYN,573
AA(?) = 0.5 * (A(5877+M)+A(5471+M))
AA(3$21) = 0.333 * (A(5877+M$21)+A(5878+M$21))
1                               +A(5879+M$21))
AA(24) = 0.5 * (A(5898+M) + A(5899+M))
AAA(1$600) = ORVXPND(AA(1$24),HW$AAA(1$600))
A(5876+M$24) = ORVCMPRS(A(5252+M$600),RW8A(5876+M$24))
D1 = A(5277+M$573)
D2 = A(658H+M$573)-A(652+M$573)+A(1451+M$573)
1                               -A(1952+M$573)
A(5277+M$573) = D1 + D2
A(5251+M$600) = ORVCTRL(AAA(1$600),RW8A(5251+M$600))
A(5251+M$600) = ORVCTRL(0.0,0X8A(5251+M$600))
FREE

```

```

C
C      T3 = SECOND(CP)
C      PRINT 150, T3
C
C      .....FIFTH ENVELOPE PRINTOUT ROUTINE.....
C      DO 100 L=NHALF,NMAX,NHALF
C      IF(N,FO,L)GO TO 101
C 100 CONTINUE
C      IF(N,FO,NMAX)GO TO 101
C      GO TO 199
C
C      .....AT HORIZONTAL SYMMETRY PLANE.....
C 101 IF(N,FO,NMAX)IPUN=1
C      PRINT 102, N
C 102 FORMAT(1H1,52X,27HF7 ENVELOPE FOR TIME STEP =,I5,
C           1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
C      CALL FNU(3851,FC,TPUN)
C
C      PRINT 104, N
C 104 FORMAT(1H1,52X,27HGX ENVELOPE FOR TIME STEP =,I5,
C           1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
C      CALL FNU(4526,3,77F+6,TPUN)
C
C      PRINT 105, N
C 105 FORMAT(1H1,52X,27HGY ENVELOPE FOR TIME STEP =,I5,
C           1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
C      CALL FNU(5226,3,77F+6,TPUN)
C
C      .....AT VERTICAL SYMMETRY PLANE.....
C      PRINT 106, N
C 106 FORMAT(1H1,52X,27HGX ENVELOPE FOR TIME STEP =,I5,
C           1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
C      CALL FNU(3F76,FC,TPUN)
C
C      PRINT 108, N
C 108 FORMAT(1H1,52X,27HGY ENVELOPE FOR TIME STEP =,I5,
C           1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
C      CALL FNU(4F51,3,77F+5,TPUN)
C
C      PRINT 109, N
C 109 FORMAT(1H1,52X,27HFY ENVELOPE FOR TIME STEP =,I5,
C           1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
C      CALL FNU(2F76,FC,TPUN)
C
C 100 CONTINUE
C 200 CONTINUE
C 201 T4 = SECOND(CP)
C      PRINT 150, T4
C      STOP
C      END

SUBROUTINE FNU(LOCA,SCALE,TPUNCH)
      DIMENSION A(EL4536),IP(2400),MN(25)
      COMMON A

```

```

C
      DO A I=1,24
      R NN(I) = I
C
      DO 1 LY=2,100
      LOC = LOCA + (LY-1)*5936
      LOCI = 1 + (LY-1)*25
      IP(LOCI:25) = SCALE * A(LOC:25)
1   A(LOC:25) = 0.

C
      IF(IPUNCH.EQ.0)GO TO 4
      DO 2 LY=2,100
      LOCI = 5 + (LY-1)*25
      LOCII = LOCI + 19
2   WRITE(P,3) (IP(LL),LL=LOCI,LOCII)
3   FORMAT(10I6)

C
4   DO 5 LY=2,100
      LYY = 102 - LY
      LOCI = 5 + (LYY-1)*25
      LOCII = LOCI + 19
5   PRINT 6, LYY, (IP(LL),LL=LOCI,LOCII)
6   FORMAT(IX,I3,5X,20I6)
      PRINT 7, (NN(LL),LL=5,24)
7   FORMAT(//,8X,20I6)

C
      RETURN
      END

```

2.4 Problem D -- Task 2, Case 2

(Section 4.2 of Volume 1)

The following 12 pages list the computer program for the 24 x 100 x 48 cell -- 1800 time step run of Problem D. The problem solved is penetration of a 12.8 cm diameter, 28 cm long, missile guidance section by a 300 MHz plane wave at axial incidence, for the case of the interior dielectric components, metal components, and wires modeled.

```

PROGRAM FDTP(INPUT,OUTPUT,TAPE60=INPUT,TAPEH=TAPF8)
C
C RUN TASK2-- STEADY 300 MHZ PLANE WAVE IRRADIATION OF A
C 12.8 CM DIAMETER MISSILE GUIDANCE SECTION
C CASE II- INTERIOR METAL AND DIELECTRIC COMPONENTS MODELED
C INCIDENT WAVE COMPONENTS ARE EZ AND HX
C 24 X 100 X 48 CELL CUBIC SPACE LATTICE IS USED
C UNIT CELL DIAMETER = DX = 0.33 CM = WAVELENGTH/300
C EVEN SYMMETRY ABOUT LATTICE PLANE X = 24.5*DX IS ASSUMED
C SOFT TEM WAVE SOURCE CONDITION IS USED AT PLANE Y = 3.0*DX
C SOFT LATTICE TRUNCATIONS ARE USED
C PROGRAM IS OPTIMIZED FOR THE CDC STAR-100
C
REAL MUR, MUZ
DIMENSION A(1565500), Z(15500), AAA(1200), BUF(600), AA(48),
1 DD(24), DE(48), DF(48), CA(9), CB(9), EPS(9), SIG(9)
COMMON A,
DESCRIPTOR D1,D2,D3,D4,D5,D6,NFD,A1,A2,BU,BV,BW,HX,HY,HZ
BIT BU,BBU(600),BV,BBV(1200),BW,BBW(1200),HX,BBX(1200),
1 BY,BBY(24),BZ,BHZ(48)
ASSIGN BU,RBU(1:600)
ASSIGN BV,BRV(1:1200)
ASSIGN BW,BBW(1:1200)
ASSIGN BX,BBX(1:1200)
ASSIGN BY,BBY(1:24)
ASSIGN BZ,BHZ(1:48)
ASSIGN D4,DD(1:24)
ASSIGN D5,DE(1:48)
ASSIGN D6,DF(1:48)
T1 = SECOND(CP)
PRINT 150, T1
150 FORMAT(F20.5)
C
C .....I. PROBLEM PARAMETERS.....
FREQ = 3.0E+8
DX = 0.01/3.0
MPR = 9
DATA EPS /1.0, 1.0, 1.0, 5.5, 4.5, 5.3, 1.0, 1.0, 8.0/
DATA SIG /0.0, 3.7E+7, 0.025, 0.0024, 0.0008, 0.0, 6.6E+6,
1 3.7E+7, 0.01/
NMAX = 1800
C
C .....II. BASIC AND DERIVED CONSTANTS.....
PI = 3.14159265
MUZ = 4.0 * PI * 1.0E-7
EPSZ = 8.854E-12
DT = DX / 6.0E+8
NHALF = 0.5 / FREQ / DT
P = DT / 2.0 / EPSZ
RA = DT**2 / DX**2 / MUZ / EPSZ
RB = DT / DX / MUZ
RC = 1.0E+4 / RB

```

```

RD = 2.0 * PI * FREQ * DT
IPUN = 0
C
CA(1:9) = 0.
CB(1:9) = 0.
BW = QAVMK0(1,25$HW)
BX = QAVMKZ(24,25$RX)
DO 2 I=1,MPR
EAF = R * SIG(I) / EPS(I)
CA(I) = (1.0 - EAF) / (1.0 + EAF)
2 CR(I) = RA / EPS(I) / (1.0 + EAF)
C
C      ....III. LOAD VECTOR A.....
C      ....ZERO INITIAL FIELDS.....
Z(1:15500) = 0.
A(1:15500) = 0.
A(1550001:15500) = 0.
C
C      ....TYPE OF MEDIUM.....
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
4 FORMAT(75F1.0)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
DO 5 J=2,6
JDEL = (J-1) * 15500
5 A(JDEL+1:15500) = Z(1:15500)
C
DO 55 J=7,14
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
JDEL = (J-1) * 15500
55 A(JDEL+1:15500) = Z(1:15500)
C
DO 6 JA=15,71,7
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
JDEL = (JA-1) * 15500
A(JDEL+1:15500) = Z(1:15500)
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
DO 6 JR=1,6
JDEL = (JA+JR-1) * 15500
6 A(JDEL+1:15500) = Z(1:15500)
DO 7 J=93,100
JDEL = (J-1) * 15500
7 A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)

```

```

DO 8 J=75,77
JDEL = (J-1) * 15500
8 A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
J = 78
JDEL = (J-1) * 15500
A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
J = 79
JDEL = (J-1) * 15500
A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
DO 9 J=80,84
JDEL = (J-1) * 15500
9 A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
J = 85
JDEL = (J-1) * 15500
A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
DO 10 J=86,87
JDEL = (J-1) * 15500
10 A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
DO 11 J=88,91
JDEL = (J-1) * 15500
11 A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
J = 92
JDEL = (J-1) * 15500
A(JDEL+1:15500) = Z(1:15500)
C
C      .....PARTIAL SYMMETRY ABOUT Z = 24.0*UX.....
DO 12 J=2,100
JDEL = (J-1) * 15500
KMAX = 49
DO 12 JA=1,3

```

```

JR = JDEL + (JA-1)*2500 + 1
BUF(1:600) = A(JB:600)
BU = RUF(1:600).GT.6.5
BUF(1:600) = Q8VCTRL(3.0,BU:BUF(1:600))
IF(JA.EQ.3)KMAX=48
A(JB+600:25) = BUF(576:25)
DO 12 K=1,24
KA = (K-1) * 25
KB = (KMAX-K) * 25
12 A(JB+KB:25) = BU(KA+1:25)
C
C      ....NON-SYMMETRIC GROUND WIRE.....
DO 13 J=43,57
JDEL = (J-1) * 15500
A(JDEL+3199) = 7.0
A(JDEL+3224) = 7.0
13 A(JDEL+5699) = 7.0
C
DO 14 K=18,28
KDEL = (K-1)*25 + 24
A(JDEL+2500+KDEL) = 7.0
A(JDEL+5000+KDEL) = 7.0
14 A(JDEL+20500+KDEL) = 7.0
C
C      ....MEDIA COEFFICIENTS.....
ASSIGN A1,.DYN.1200
ASSIGN A2,.DYN.1200
ASSIGN NFD,.DYN.1200
A1 = 0.
A2 = 0.
DO 21 J=2,100
JDEL = (J-1) * 15500
DO 21 JA=1,3
JB = (JA-1)*2500 + 1
JC = JB + 1250
NFD = A(JDEL+JB:1200)
DO 20 JJ=1,MPR
BV = NFD.EQ.JJ
A1 = Q8VCTRL(CA(JJ),BV:A1)
20 A2 = QAVCTRL(CB(JJ),BV:A2)
A(JDEL+JR:1200) = A1
21 A(JDEL+JC:1200) = A2
FREE
C
T2 = SECOND(CP)
PRINT 150, T2
C
C      ....IV. TIME-STEPPING LOOP.....
DO 210 N=1,NMAX
TERM = SIN(FLOAT(N)*RD) * RB
MCALL = 3 + IFIX(FLOAT(N)/6.0)
IF(MCALL.GT.33)MCALL=33

```

```

C
C      .....TRANSVERSE PLANE NO. 1.....
C      .....EX, EZ TRUNCATIONS.....
A(7501:1250) = A(1:1250)
A(1:1250) = A(23001:1250)
A(10201:1250) = A(1251:1250)
A(1251:1250) = A(25701:1250)
C
C      .....EY ITERATION.....
ASSIGN D1,.DYN.1174
ASSIGN D2,.DYN.1174
ASSIGN D3,.DYN.1174
C
A(8826) = 0.5 * (A(10076)+A(10077))
A(8827:22) = 0.333 * (A(10076:22)+A(10077:22)+A(10078:22))
A(8849) = 0.333 * (A(10098)+2.0*A(10099))
A(10076:24) = A(8851:24)
C
A(10026) = 0.5 * (A(10101)+A(10102))
A(10027:22) = 0.333 * (A(10101:22)+A(10102:22)+A(10103:22))
A(10049) = 0.333 * (A(10123)+2.0*A(10124))
A(10101:24) = A(10001:24)
C
D1 = CA(3) * A(8851:1174)
D2 = A(11551:1174)-A(11526:1174)+A(14201:1174)-A(14202:1174)
D3 = CB(3) * D2
A(8851:1174) = D1 + D3
FREE
C
C      .....TRANSVERSE PLANES 2 - 100.....
DO 82 JY=1,MCALL
JDEL = (JY-1) * 46500
C
C      .....EX ITERATION.....
ASSIGN D1,.DYN.1173
ASSIGN D2,.DYN.1173
ASSIGN D3,.DYN.1173
C
DO 30 MA=1,3
M = JDEL + 15500*(MA-1)
C
C      .....SOFT LATTICE TRUNCATIONS.....
A(23002+M) = 0.5 * (A(24252+M)+A(24253+M))
A(23003+M:21) = 0.333 * (A(24252+M:21)+A(24253+M:21)
1                               +A(24254+M:21))
A(23024+M) = 0.5 * (A(24273+M)+A(24274+M))
A(24257+M:23) = A(23027+M:23)
C
A(24202+M) = 0.5 * (A(24277+M)+A(24278+M))
A(24203+M:21) = 0.333 * (A(24277+M:21)+A(24278+M:21)
1                               +A(24279+M:21))
A(24224+M) = 0.5 * (A(24298+M)+A(24299))

```

A(24277+M\$23) = A(24177+M\$23)

C

CMAIN EX LOOPS.....

D1 = A(15527+M\$1173) * A(23027+M\$1173)

D2 = A(29702+M\$1173)-A(14202+M\$1173)+A(28352+M\$1173)

1 -A(28377+M\$1173)

D3 = A(16777+M\$1173) * D2

A(23027+M\$1173) = D1 + D3

C

CEX ENVELOPE COMPUTATION.....

D4 = VAHS(A(23601+M\$24);D4)

BY = D4.GT.A(24301+M\$24)

30 A(24301+M\$24) = Q8VCTRL(D4,BY;A(24301+M\$24))

FREE

C

CEY ITERATION.....

ASSIGN D1,,DYN,1174

ASSIGN D2,,DYN,1174

ASSIGN D3,,DYN,1174

C

DO 40 MA=1,3

M = JDEL + 15500*(MA-1)

C

CSOFT LATTICE TRUNCATIONS.....

A(24326+M) = 0.5 * (A(25576+M)+A(25577+M))

A(24327+M\$22) = 0.333 * (A(25576+M\$22)+A(25577+M\$22))

1 +A(25578+M\$22))

A(24349+M) = 0.333 * (A(25598+M)+2.0*A(25599+M))

A(25576+M\$24) = A(24351+M\$24)

C

A(25526+M) = 0.5 * (A(25601+M)+A(25602+M))

A(25527+M\$22) = 0.333 * (A(25601+M\$22)+A(25602+M\$22))

1 +A(25603+M\$22))

A(25549+M) = 0.333 * (A(25623+M)+2.0*A(25624+M))

A(25601+M\$24) = A(25501+M\$24)

C

CMAIN EY LOOPS.....

D1 = A(18026+M\$1174) * A(24351+M\$1174)

D2 = A(27051+M\$1174)-A(27026+M\$1174)+A(29701+M\$1174)

-A(29702+M\$1174)

1

D3 = A(19276+M\$1174) * D2

A(24351+M\$1174) = D1 + D3

C

CEY ENVELOPE COMPUTATION.....

D4 = VAHS(A(24926+M\$24);D4)

BY = D4.GT.A(25626+M\$24)

A(25626+M\$24) = Q8VCTRL(D4,BY;A(25626+M\$24))

C

D5 = Q8VCMPRS(A(24325+M\$1200),BX;D5)

D6 = VAHS(D5;D6)

BZ = D6.GT.A(25651+M\$48)

40 A(25651+M\$48) = Q8VCTRL(D6,BZ;A(25651+M\$48))

FREE

```

C
C      ....EZ ITERATION.....
C      ASSIGN D1,,DYN.1199
C      ASSIGN D2,,DYN.1199
C      ASSIGN D3,,DYN.1199
C
C      DO 50 MA=1,3
C      M = JDEL + 15500*(MA-1)
C
C      ....MAIN EZ LOOPS.....
C      D1 = A(20501+M$1199) * A(25701+M$1199)
C      D2 = A(28352+M$1199)-A(28351+M$1199)+A(11526+M$1199)
C      1          -A(27026+M$1199)
C      D3 = A(21751+M$1199) * D2
C      A(25701+M$1199) = D1 + D3
C
C      ....EZ SOFT TEM WAVE SOURCE CONDITION.....
C      IF(JY.GE.2.OR.LF.2)GO TO 47
C      A(56701$1199) = TERM + A(56701$1199)
C
C      ....EZ ENVELOPE COMPUTATION.....
C      47 A(26926+M$24) = 0.5 * (A(26276+M$24)+A(26301+M$24))
C      D4 = VABS(A(26926+M$24);D4)
C      BY = D4.GT.A(26951+M$24)
C      A(26951+M$24) = Q8VCTRL(D4,BY;A(26951+M$24))
C
C      D5 = Q8VCMPRS(A(25700+M$1200),HX;D5)
C      D6 = VABS(D5;D6)
C      BZ = D6.GT.A(26976+M$48)
C      50 A(26976+M$48) = Q8VCTRL(D6,BZ;A(26976+M$48))
C
C      ....HX ITERATION.....
C      DO 60 MA=1,3
C      M = JDEL + 15500*(MA-1)
C
C      ....MAIN HX LOOPS.....
C      D1 = A(11526+M$1199)
C      D2 = A(8851+M$1199)-A(8826+M$1199)+A(10201+M$1199)
C      1          -A(25701+M$1199)
C      A(11526+M$1199) = D1 + D2
C
C      ....HX ENVELOPE COMPUTATION.....
C      A(12751+M$24) = 0.5 * (A(12101+M$24)+A(12126+M$24))
C      D4 = VARS(A(12751+M$24);D4)
C      BY = D4.GT.A(12776+M$24)
C      A(12776+M$24) = Q8VCTRL(D4,BY;A(12776+M$24))
C
C      D5 = Q8VCMPRS(A(11525+M$1200),HX;D5)
C      D6 = VABS(D5;D6)
C      BZ = D6.GT.A(12801+M$48)
C      60 A(12801+M$48) = Q8VCTRL(D6,BZ;A(12801+M$48))
C      FREE

```

```

C
C      ....HY ITERATION.....
ASSIGN D1,,DYN.1198
ASSIGN D2,,DYN.1198
C
DO 70 MA=1,3
M = JDEL + 15500*(MA-1)
C
      ....SOFT LATTICE TRUNCATION.....
AA(1) = 0.5 * (A(29601+M)+A(29602+M))
AA(2+46) = 0.333 * (A(29601+M+46)+A(29602+M+46)
           +A(29603+M+46))
1
AA(48) = 0.5 * (A(29647+M)+A(29648+M))
AAA(1+1200) = Q8VXPND(AA(1+48),BW$AAA(1+1200))
A(29601+M+48) = Q8VCMPRS(A(28352+M+1200),BW$A(29601+M+48))
C
C      ....MAIN HY LOOPS.....
D1 = A(28352+M+1198)
D2 = A(25702+M+1198)-A(25701+M+1198)+A(23002+M+1198)
     -A(23027+M+1198)
1
A(28352+M+1198) = D1 + D2
C
A(28351+M+1200) = Q8VCTRL(AAA(1+1200),BW$A(28351+M+1200))
A(28351+M+1200) = Q8VCTRL(0.0,BX$A(28351+M+1200))
C
C      ....HY ENVELOPE COMPUTATION.....
A(29576+M+24) = 0.5 * (A(28926+M+24)+A(28951+M+24))
D4 = VABS(A(29576+M+24))D4)
HY = D4.GT.A(29651+M+24)
70 A(29651+M+24) = Q8VCTRL(D4,BY$A(29651+M+24))
FREE
C
C      ....HZ ITERATION.....
ASSIGN D1,,DYN.1173
ASSIGN D2,,DYN.1173
C
DO 80 MA=1,3
M = JDEL + 15500*(MA-1)
C
      ....SOFT LATTICE TRUNCATION.....
AA(2) = 0.5 * (A(15427+M)+A(15428+M))
AA(3+45) = 0.333 * (A(15427+M+45)+A(15428+M+45)
           +A(15429+M+45))
1
AA(48) = 0.5 * (A(15472+M)+A(15473+M))
AAA(1+1200) = Q8VXPND(AA(1+48),BW$AAA(1+1200))
A(15426+M+48) = Q8VCMPRS(A(14177+M+1200),BW$A(15426+M+48))
C
C      ....MAIN HZ LOOPS.....
D1 = A(14202+M+1173)
D2 = A(23027+M+1173)-A(7527+M+1173)+A(8851+M+1173)
     -A(8852+M+1173)
1
A(14202+M+1173) = D1 + D2

```

C
 A(14176+M\$1200) = Q8VCTRL(AAA(1\$1200),HW\$A(14176+M\$1200))
 A(14176+M\$1200) = Q8VCTRL(0.0,FX\$A(14176+M\$1200))
 C
 C HZ ENVELOPE COMPUTATION
 D4 = VABS(A(14776+M\$24)\$D4)
 BY = D4.GT.A(15476+M\$24)
 80 A(15476+M\$24) = Q8VCTRL(D4,BY\$A(15476+M\$24))
 FREE
 82 CONTINUE
 IF(MCALL.LE.32) GO TO 94
 C
 C TRANSVERSE PLANE NO. 101
 M = 99 * 15500
 C
 C EX, EZ TRUNCATIONS
 A(23001+M\$1250) = A(15501+M\$1250)
 A(15501+M\$1250) = A(16751+M\$1250)
 A(16751+M\$1250) = A(7501+M\$1250)
 C
 A(25701+M\$1250) = A(18001+M\$1250)
 A(18001+M\$1250) = A(19251+M\$1250)
 A(19251+M\$1250) = A(10201+M\$1250)
 C
 C HX ITERATION
 ASSIGN D1,.DYN.1199
 ASSIGN D2,.DYN.1199
 D1 = A(11526+M\$1199)
 D2 = A(8851+M\$1199)-A(8826+M\$1199)+A(10201+M\$1199)
 1 -A(25701+M\$1199)
 A(11526+M\$1199) = D1 + D2
 C
 A(12751+M\$24) = 0.5 * (A(12101+M\$24)+A(12126+M\$24))
 D4 = VABS(A(12751+M\$24)\$D4)
 BY = D4.GT.A(12776+M\$24)
 A(12776+M\$24) = Q8VCTRL(D4,BY\$A(12776+M\$24))
 C
 D5 = Q8VCMPRS(A(11525+M\$1200),HX\$D5)
 D6 = VARS(D5\$U6)
 BZ = D6.GT.A(12801+M\$48)
 A(12801+M\$48) = Q8VCTRL(D6,BZ\$A(12801+M\$48))
 FREE
 C
 C HZ ITERATION
 ASSIGN D1,.DYN.1173
 ASSIGN D2,.DYN.1173
 AA(2) = 0.5 * (A(15427+M)+A(15428+M))
 AA(3\$45) = 0.333 * (A(15427+M\$45)+A(15428+M\$45)
 1 +A(15429+M\$45))
 AA(48) = 0.5 * (A(15472+M)+A(15473+M))
 AAA(1\$1200) = Q8VXPND(AA(1\$48),BW\$AAA(1\$1200))
 A(15426+M\$48) = Q8VCMPRS(A(14177+M\$1200),HW\$A(15426+M\$48))
 C

```

D1 = A(14202+M$1173)
D2 = A(23027+M$1173)-A(7527+M$1173)+A(8851+M$1173)
1
A(14202+M$1173) = D1 + D2
A(14176+M$1200) = QBVCTRL(AAA(1$1200),BW$A(14176+M$1200))
A(14176+M$1200) = QBVCTRL(0.0,BX$A(14176+M$1200))
C
D4 = VARS(A(14776+M$24)+D4)
HY = D4.GT.A(15476+M$24)
A(15476+M$24) = QBVCTRL(D4+HY+A(15476+M$24))
FREE
94 T3 = SECOND(CP)
PRINT 150, T3
C
C      ....FIELD ENVELOPE PRINTOUT ROUTINE.....
DO 100 L=NHALF,NMAX,NHALF
IF(N.EQ.L)GO TO 101
100 CONTINUE
IF(N.EQ.NMAX)GO TO 101
GO TO 199
C
C      .....AT HORIZONTAL OBSERVATION PLANE.....
101 IF(N.EQ.NMAX)IPUN=1
PRINT 102, N
102 FORMAT(1H1,52X,27HEX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(18801,20,RC,IPUN)
C
PRINT 103, N
103 FORMAT(1H1,52X,27HEY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(10126,20,RC,IPUN)
C
PRINT 104, N
104 FORMAT(1H1,52X,27HEZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(11451,20,RC,IPUN)
C
PRINT 105, N
105 FORMAT(1H1,52X,27HHX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL FNV(12776,20,3.77E+6,IPUN)
C
PRINT 106, N
106 FORMAT(1H1,52X,27HHY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(14151,20,3.77E+6,IPUN)
C
PRINT 107, N
107 FORMAT(1H1,52X,27HHZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL FNV(15476,20,3.77E+6,IPUN)

```

```

C
C      ....AT VERTICAL SYMMETRY PLANE.....
PRINT 108, N
108 FORMAT(1H1,52X,27HEZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
CALL FNV(11476,40,RC,IPUN)

C
PRINT 109, N
109 FORMAT(1H1,52X,27HHX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
CALL ENV(12801,40,3.77E+6,IPUN)
CUR1 = A(49*15500+10178) * RC * 73.33
CUR2 = A(78*15500+10161) * RC * 73.33
PRINT 150, CUR1
PRINT 150, CUR2

C
PRINT 110, N
110 FORMAT(1H1,52X,27HEY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
CALL ENV(10151,40,RC,IPUN)

C
199 CONTINUE
200 CONTINUE
201 T4 = SECOND(CP)
PRINT 150, T4
STOP
END

SUBROUTINE ENV(LOCA,NUM,SCALE,IPUNCH)
DIMENSION A(1565500),IP(4000),NN(50)
COMMON A

C
DO 1 I=1,50
1 NN(I) = I

C
DO 2 LY=2,100
LOC = LOCA + (LY-1)*15500 + 4
LOCI = 1 + (LY-1)*40
IP(LOCI:NUM) = SCALE * A(LOC:NUM)
2 A(LOC:NUM) = 0.

C
IF(IPUNCH.EQ.0)GO TO 5
DO 3 LY=2,100
LOCI = 1 + (LY-1)*40
LOCII = LOCI - 1 + NUM
3 WRITE(8,4) (IP(LL),LL=LOCI,LOCII)
4 FORMAT(10I6)

C
5 LXM = NUM/20
DO 8 LX=1,LXM
LXA = 1 + (LX-1)*20
LA = LXA + 4
LZ = LA + 19

```

```
DO 6 LY=2,100
LYY = 102 - LY
LOCI = LXA + (LYY-1)*40
LOCII = LOCI + 19
6 PRINT 7, LYY, (IP(LL),LL=LOCI,LOCII)
7 FORMAT(IX,I3,5X,20I6)
8 PRINT 9, (NN(LL),LL=LA,LZ)
9 FORMAT(//,8X,20I6,/////)
C
RETURN
END
```

2.5 Problem E -- Task 5, Case 1
(Section 7.4.1 of Volume 1)

The following 10 pages list the computer program for the 24 x 163 x 24 cell -- 800 time step run of Problem E. The problem solved is a hybrid method of moments/FD-TD analysis of penetration of a 19.0 cm diameter, 68.5 cm long, open-ended aluminum cylinder by a 300 MHz plane wave at axial incidence.

```

PROGRAM FITD (INPUT,OUTPUT,TAPE60=INPUT,TAPFR=TAPEA)
C
C RUN TASKS-- INTERFACING THE FU-TD METHOD WITH THF METHOD OF
C MOMENTS
C CASE I- STEADY 300 MHZ TFM IRRADIATION OF A 19.0 CM
C DIAMETER, 68.5 CM LONG. OPEN-ENDED ALUMINUM
C CYLINDER
C AXIAL-INCIDENCE PLANE WAVE WITH COMPONENTS FZ AND MX
C MODIFIED USING SCHELKUNOFF EQUIVALENCE THEOREM WITH
C PROF. DON WILTON'S M-O-M APERTURE CURRENT DATA
C 24 X 163 X 24 CELL CURIC SPACE LATTICE IS USED
C UNIT CELL DIAMETER = DX = 0.5 CM = WAVELENGTH/200
C EVEN SYMMETRY ABOUT LATTICE PLANES X = 24.5*DX AND
C Z = 24.0*DX IS ASSUMED
C SOFT LATTICE TRUNCATIONS ARE USED
C PROGRAM IS OPTIMIZED FOR THE CDC STAR-100
C
      RFAL 1IR, MUZ, JXMAG, JXPHA, JXSRC, JZMAG, JZPHA, JZSRC
      DIMENSION A(973504),CEXR(97800),CEYR(97800),CEZR(97800),
      1          Z(5436),AAA(600),JXMAG(600),JXPHA(600),JXSRC(600),
      2          JZMAG(600),JZPHA(600),JZSRC(600),AA(25),DD(24),
      3          DF(24),CA(9),CH(9),FPS(3),SIG(3)
      COMMON A,CEXR,CEYR,CEZR
      DESCRIPTOR D1,D2,D3,D4,D5,NFD,A1,A2,RV,BW,BX,RY,PQ
      RIT BV,HRR(600),BW,HRW(600),BX,HBX(600),BY,BHY(24),
      1          RQ,BHQ(600)
      ASSIGN RQ,HPO(1:600)
      ASSIGN RV,HRR(1:600)
      ASSIGN BW,HRW(1:600)
      ASSIGN BX,PBX(1:600)
      ASSIGN BY,PRY(1:24)
      ASSIGN D4,DD(1:24)
      ASSIGN D5,DF(1:24)
      T1 = SFCOND(CP)
      PRINT 150, T1
      150 FORMAT (F20.5)
C
C .....I. PROBLEM PARAMETERS.....
      FREQ = 3.0E+8
      DX = 0.005
      MPR = 3
      DATA FPS/ 1.0,    1.0,    1.0 /
      DATA SIG/ 0.0,    3.7E+7,  0.01 /
      NMAX = 800
C
C .....II. BASIC AND DERIVED CONSTANTS.....
      PI = 3.14159265
      MUZ = 4.0 * PI * 1.0E-7
      EPSZ = 8.854E-12
      DT = DX / 6.0E+8
      NHALF = 0.5 / FREQ / DT
      R = DT / 2.0 / EPSZ

```

RA = DT**2 / DX**2 / MUZ / EPSZ
RR = DT / DX / MUZ
RC = 1.0 / RR
RD = 2.0 * PI * FRFQ * DT
IPUN = 0

C

CA(1:9) = 0.
CR(1:9) = 0.
BW = QAVMK0(1.25*BW)
RX = QAVMKZ(24.25*BX)
DO 2 I=1,MPR
EAF = R * SIG(I) / EPS(I)
CA(I) = (1.0-EAF) / (1.0+EAF)

2 CR(I) = RA / EPS(I) / (1.0+EAF)

C

CIII. LOAD VECTOR A.....
CZERO INITIAL FIELDS.....

Z(1:5936) = 0.
A(1:5936) = 0.
A(967569:5936) = 0.

C

CTYPE OF MEDIUM.....
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
4 FORMAT (75F1.0)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
DO 5 J=2,13
JDEL = (J-1) * 5936
5 A(JDEL+1:5936) = Z(1:5936)
DO 6 J=152,163
JDFL = (J-1) * 5936
6 A(JDEL+1:5936) = Z(1:5936)

C

READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
DO 7 J=14,150
JDFL = (J-1) * 5936
7 A(JDEL+1:5936) = Z(1:5936)

C

READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=2601,3200)
READ(60,4,END=201,ERR=201) (Z(I),I=1301,1900)
J = 151
JDEL = (J-1) * 5936
A(JDEL+1:5936) = Z(1:5936)

C

CAPEKTURE EXCITATION.....
READ(60,10,END=201,ERR=201) (JXMAG(I),I=1,600)
RFAD(60,11,END=201,ERR=201) (JXPHA(I),I=1,600)
RFAD(60,10,END=201,ERR=201) (JZMAG(I),I=1,600)
RFAD(60,11,END=201,ERR=201) (JZPHA(I),I=1,600)
10 FORMAT (12F6.2,/,13F6.2)

11 FORMAT (25F3.0)

C

CMEDIA COEFFICIENTS.....

ASSIGN A1,.DYN.600

ASSIGN A2,.DYN.600

ASSIGN NFD,.DYN.600

A1 = 0.

A2 = 0.

DO 23 J=2,163

JDEL = (J-1) * 5936

JDEM = (J-1) * 600

C

NFD = A(JDEL+1:600)

DO 20 JJ=1,MPR

BV = NFD.EQ.JJ

A1 = QAVCTRL(CA(JJ),RV\$A1)

20 A2 = QAVCTRL(CH(JJ),RV\$A2)

A(JDEL+1:600) = A1

CFXR(JDEM+1:600) = A2

C

NFD = A(JDEL+1301:600)

DO 21 JJ=1,MPR

BV = NFD.EQ.JJ

A1 = QAVCTRL(CA(JJ),RV\$A1)

21 A2 = QAVCTRL(CH(JJ),RV\$A2)

A(JDEL+1301:600) = A1

CEYB(JDEM+1:600) = A2

C

NFD = A(JDEL+2601:600)

DO 22 JJ=1,MPR

BV = NFD.EQ.JJ

A1 = QAVCTRL(CA(JJ),BV\$A1)

22 A2 = QAVCTRL(CH(JJ),BV\$A2)

A(JDEL+2601:600) = A1

23 CEZR(JDEM+1:600) = A2

FREE

C

T2 = SECOND(CP)

PRINT 150, T2

C

CIV. TIME-STEPPING LOOP.....

DO 200 N=1,NMAX

C

CCOMPUTE APERTURE SOURCE CURRENTS.....

ASSIGN D1,.DYN.600

ASSIGN D2,.DYN.600

ASSIGN D3,.DYN.600

C

D1 = FLOAT(N) - JXPHA(1:600)

BQ = D1.LT.0.0

D1 = QAVCTRL(0.0,BQ*D1)

D2 = D1 * RD

```

D3 = VSIN(D2*D3)
JXSRC(18600) = -1.0 * JXMAG(18600) * CR(1) * D3
C
D1 = FLOAT(N) - JZPHA(18600)
BQ = D1.LT.0.0
D1 = Q8VCTRL(0.0,BQ*D1)
D2 = D1 * RD
D3 = VSIN(D2*D3)
JZSRC(18600) = JZMAG(18600) * CR(1) * D3
FREE
C
MCALL = 7 + IFIX(FLOAT(N)/6.0)
IF(MCALL.GT.54)MCALL=54
C
C      .....TRANSVERSE PLANE NO. 1.....
C      ....EX. EZ TRUNCATIONS.....
A(626:625) = A(18625)
A(18625) = A(6562:625)
A(3226:625) = A(2601:625)
A(2601:625) = A(9162:625)
C
C      ....FY ITERATION.....
ASSIGN D1,,DYN.574
ASSIGN D2,,DYN.574
ASSIGN D3,,DYN.574
A(1926) = 0.5 * (A(2551)+A(2552))
A(1927:22) = 0.333 * (A(2551:22)+A(2552:22)+A(2553:22))
A(1949) = 0.333 * (A(2573) + 2.0*A(2574))
A(2551:24) = A(1951:24)
D1 = CA(3) * A(1951:574)
D2 = A(3926:574) - A(3901:574) + A(5276:574) - A(5277:574)
D3 = CR(3) * D2
A(1951:574) = D1 + D3
FREE
C
C      ....TRANSVERSE PLANES 2 - 163.....
DO B2 JY=1,MCALL
JDEL = (JY-1) * 17808
JDEM = (JY-1) * 1800
C
C      ....EX ITERATION.....
ASSIGN D1,,DYN.573
ASSIGN D2,,DYN.573
ASSIGN D3,,DYN.573
C
DO 30 MA=1,3
M = JDFL + 5936*(MA-1)
MM = JDEM + 600*(MA-1)
C
C      ....SOFT LATTICE TRUNCATION.....
A(6563+M) = 0.5 * (A(7188+M)+A(7189+M))
A(6564+M:21) = 0.333 * (A(7188+M:21)+A(7189+M:21)
                           +A(7190+M:21))

```

$$A(6585+M) = 0.5 * (A(7209+M)+A(7210+M))$$

$$A(7188+M+23) = A(6588+M+23)$$

C
C MAIN EX LOOPS
D1 = A(5963+M+573) * A(6588+M+573)
D2 = A(11213+M+573)-A(5277+M+573)+A(10513+M+573)
1 -A(10538+M+573)
D3 = CFXH(627+MM+573) * D2
A(6588+M+573) = D1 + D3

C
C JX APERTURE SOURCE CONDITION
IF(M,F0,12*5936) A(6562+M+600)=JXSRC(18600)+A(6562+M+600)
30 CONTINUE
FREE

C
C FY ITERATION
ASSIGN D1..DYN.574
ASSIGN D2..DYN.574
ASSIGN D3..DYN.574

C
DO 40 MA=1,3
M = JDFL + 5936*(MA-1)
MM = JDEM + 600*(MA-1)

C
C SOFT LATTICE TRUNCATION
A(7862+M) = 0.5 * (A(8487+M)+A(8488+M))
A(7863+M+22) = 0.333 * (A(8487+M+22)+A(8488+M+22)
1 +A(8489+M+22))
A(7885+M) = 0.333 * (A(8509+M) + 2.0*A(8510+M))
A(8487+M+24) = A(7887+M+24)

C
C MAIN EY LOOPS
D1 = A(7262+M+574) * A(7887+M+574)
D2 = A(9862+M+574)-A(9837+M+574)+A(11212+M+574)
1 -A(11213+M+574)
D3 = CEYR(626+MM+574) * D2
A(7887+M+574) = D1 + D3

C
C EY ENVELOPE COMPUTATION
D4 = QRVCMPRS(A(7861+M+600),BX*D4)
D5 = VARS(D4,D5)
BY = D5.GT.A(8512+M+24)
40 A(8512+M+24) = Q8VCTRL(D5,HYIA(8512+M+24))
FREE

C
C EZ ITERATION
ASSIGN D1..DYN.599
ASSIGN D2..DYN.599
ASSIGN D3..DYN.599

C
DO 50 MA=1,3
M = JDFL + 5936*(MA-1)
MM = JDEM + 600*(MA-1)

```

C
C      ....MAIN FZ LOOPS.....
D1 = A(8537+M$599) * A(9162+M$599)
D2 = A(10513+M$599)-A(10512+M$599)+A(3901+M$599)
1          -A(9837+M$599)
D3 = CFZR(601+MM$599) * D2
A(9162+M$599) = D1 + D3
C
C      ....JZ APERTURE SOURCE CONDITION.....
IF(M,FQ,12*5936) A(9162+M$600) = JZSRC(1+600)+A(9162+M$600)
C
C      ....EZ ENVELOPE COMPUTATION.....
D4 = VARS(A(9737+M$24)+D4)
RY = D4.GT.A(9787+M$24)
A(9787+M$24) = Q8VCTRL(D4,RY+A(9787+M$24))
D4 = Q8VCMPPRS(A(9161+M$600),BX+D4)
D5 = VARS(D4+D5)
RY = D5.GT.A(9812+M$24)
50 A(9812+M$24) = Q8VCTRL(D5,RY+A(9812+M$24))
C
C      ....HX ITERATION.....
DO 60 MA=1,3
M = JDEL + 5936*(MA-1)
C
C      ....MAIN HX LOOPS.....
D1 = A(3901+M$599)
D2 = A(1951+M$599)-A(1926+M$599)+A(3226+M$599)
1          -A(9162+M$599)
A(3901+M$599) = D1 + D2
C
C      ....HX ENVELOPE COMPUTATION.....
D4 = VABS(A(4476+M$24)+D4)
RY = D4.GT.A(4526+M$24)
A(4526+M$24) = Q8VCTRL(D4,RY+A(4526+M$24))
D4 = Q8VCMPPRS(A(3900+M$600),MX+D4)
D5 = VARS(D4+D5)
RY = D5.GT.A(4551+M$24)
60 A(4551+M$24) = Q8VCTRL(D5,RY+A(4551+M$24))
FREE
C
C      ....HY ITERATION.....
ASSIGN D1,,.DYN.598
ASSIGN D2,,.DYN.598
C
DO 70 MA=1,3
M = JDEL + 5936*(MA-1)
C
C      ....SOFT LATTICE TRUNCATION.....
AA(1) = 0.5 * (A(11137+M)+A(11138+M))
AA(2+22) = 0.333 * (A(11137+M+22)+A(11138+M+22)
1          +A(11139+M+22))
AA(24) = 0.333 * (A(11159+M) + 2.0*A(11160+M))
AAA(1+600) = Q8VXPND(AA(1+24),BW;AAA(1+600))

```

$A(11137+M:24) = Q8VCMPRS(A(10513+M:600),BW;A(11137+M:24))$
 C
 C MAIN HY LOOPS

$D1 = A(10513+M:598)$
 $D2 = A(9163+M:598) - A(9162+M:598) + A(6563+M:598)$
 1 $- A(6588+M:598)$
 $A(10513+M:598) = D1 + D2$

C
 $A(10512+M:600) = Q8VCTRL(AAA(1:600),BW;A(10512+M:600))$
 $A(10512+M:600) = Q8VCTRL(0.0,BX;A(10512+M:600))$

C
 C HY ENVELOPE COMPUTATION

$D4 = VABS(A(11087+M:24);D4)$
 $RY = D4.GT.A(11162+M:24)$
 70 $A(11162+M:24) = Q8VCTRL(D4,RY;A(11162+M:24))$
 FREE

C
 C HZ ITERATION

ASSIGN D1..DYN..573
 ASSIGN D2..DYN..573

C
 DO 80 MA=1,3
 $M = JDFL + 5936*(MA-1)$

C
 C SOFT LATTICE TRUNCATION

$AA(2) = 0.5 * (A(5877+M)+A(5878+M))$
 $AA(3:21) = 0.333 * (A(5877+M:21)+A(5878+M:21))$
 1 $+ A(5879+M:21))$
 $AA(24) = 0.5 * (A(5898+M) + A(5899+M))$
 $AAA(1:600) = Q8VXPND(AA(1:24).BW;AAA(1:600))$
 $A(5876+M:24) = Q8VCMPRS(A(5252+M:600),BW;A(5876+M:24))$

C
 C MAIN HZ LOOPS

$D1 = A(5277+M:573)$
 $D2 = A(6588+M:573) - A(652+M:573) + A(1951+M:573)$
 1 $- A(1952+M:573)$
 $A(5277+M:573) = D1 + D2$

C
 $A(5251+M:600) = Q8VCTRL(AAA(1:600),BW;A(5251+M:600))$
 80 $A(5251+M:600) = Q8VCTRL(0.0,BX;A(5251+M:600))$
 FREE

R2 CONTINUE
 IF(MCALL.LF..53) GO TO 94

C
 C TRANSVERSE PLANE NO. 164

$M = 162 * 5936$

C EX, EZ TRUNCATIONS

$A(6562+M:625) = A(5937+M:625)$
 $A(5937+M:625) = A(7237+M:625)$
 $A(7237+M:625) = A(626+M:625)$
 $A(9162+M:625) = A(8537+M:625)$

A(8537+M\$625) = A(9837+M\$625)
A(9837+M\$625) = A(3226+M\$625)

C

CHX ITERATION.....

ASSIGN D1,.DYN.599

ASSIGN D2,.DYN.599

D1 = A(3901+M\$599)

D2 = A(1951+M\$599)-A(1926+M\$599)+A(3226+M\$599)
1 -A(9162+M\$599)

A(3901+M\$599) = D1 + D2

D4 = VARS(A(4476+M\$24))D4

BY = D4.GT.A(4526+M\$24)

A(4526+M\$24) = Q8VCTRL(D4,BY:A(4526+M\$24))

D4 = Q8VCMPRS(A(3900+M\$600),BX:D4)

D5 = VARS(D4:D5)

BY = D5.GT.A(4551+M\$24)

A(4551+M\$24) = Q8VCTRL(D5,BY:A(4551+M\$24))

FREE

C

CHZ ITERATION.....

ASSIGN D1,.DYN.573

ASSIGN D2,.DYN.573

AA(2) = 0.5 * (A(5877+M)+A(5878+M))

AA(3:21) = 0.333 * (A(5877+M\$21)+A(5878+M\$21)
1 +A(5879+M\$21))

AA(24) = 0.5 * (A(5898+M) + A(5899+M))

AAA(1:600) = Q8VXPND(AA(1:24),BW:AAA(1:600))

A(5876+M\$24) = Q8VCMPRS(A(5252+M\$600),BW:A(5876+M\$24))

D1 = A(5277+M\$573)

D2 = A(6588+M\$573)-A(652+M\$573)+A(1951+M\$573)
1 -A(1952+M\$573)

A(5277+M\$573) = D1 + D2

A(5251+M\$600) = Q8VCTRL(AAA(1:600),BW:A(5251+M\$600))

A(5251+M\$600) = Q8VCTRL(0.0,BX:A(5251+M\$600))

FREE

94 T3 = SECOND(CP)

PRINT 150, T3

C

CFIELD ENVELOPE PRINTOUT ROUTINE.....

DO 100 L=NHALF,NMAX,NHALF

IF(N.EQ.L)GO TO 101

100 CONTINUE

IF(N.EQ.NMAX)GO TO 101

GO TO 199

C

CAT HORIZONTAL SYMMETRY PLANE.....

101 IF(N.EQ.NMAX)IPUN=1

PRINT 102, N

102 FORMAT(1H1,52X,27HEZ ENVELOPE FOR TIME STEP =,I5,

1 //,62X,15HPLANE Z = 24*Dx,//,2X,IHJ,/)

CALL ENV(3851,RC,IPUN)

C

```

PRINT 104, N
104 FORMAT(1H1,52X,27HHX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(4526,376.7,IPUN)

C
PRINT 105, N
105 FORMAT(1H1,52X,27HHY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(5226,376.7,IPUN)

C
C          PRINT VERTICAL SYMMETRY PLANE
PRINT 106, N
106 FORMAT(1H1,52X,27HFX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
CALL ENV(3876,RC,IPUN)

C
PRINT 108, N
108 FORMAT(1H1,52X,27HHX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
CALL ENV(4551,376.7,IPUN)

C
PRINT 109, N
109 FORMAT(1H1,52X,27HEY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HJ,/)
CALL ENV(2576,RC,IPUN)

C
199 CONTINUE
200 CONTINUE
201 T4 = SECOND(CP)
PRINT 150, T4
STOP
END

SUBROUTINE ENV(LOCA,SCALE,IPUNCH)
DIMENSION A(973504),IP(4)00),NN(25)
COMMON A

C
DO 8 I=1,25
  A(NN(I)) = I
C
DO 1 LY=2,163
  LOC = LOCA + (LY-1)*5936
  LOCI = 1 + (LY-1)*25
  IP(LOCI:25) = SCALE * A(LOC:25)
  1 A(LOC:25) = 0.
C
IF(IPUNCH.EQ.0)GO TO 4
DO 2 LY=2,163
  LOCI = 5 + (LY-1)*25
  LOCII = LOCI + 19
  2 WRITE(8,3) (IP(LL),LL=LOCI,LOCII)
  3 FORMAT(10I6)
C

```

```
4 DO 5 LY=2,163
LYY = 165 - LY
LOCI = 5 + (LYY-1)*25
LOCII = LOCI + 19
5 PRINT 6, LYY, (IP(LL),LL=LOCI,LOCII)
6 FORMAT(1X,I3,5X,20I6)
PRINT 7, (NN(LL),LL=5,24)
7 FORMAT(//,HX,20I6)
C
RETURN
END
```

2.6 Problem F -- Task 5, Case 2
(Section 7.4.2 of Volume 1)

The following 11 pages list the computer program for the 24 x 163 x 48 cell -- 800 time step run of Problem F. The problem solved is a hybrid method of moments/FD-TD analysis of penetration of a 19.0 cm diameter, 68.5 cm long, open-ended aluminum cylinder by a 300 MHz plane wave at 45° incidence relative to the cylinder axis and TM polarized.

```

PROGRAM EDTE (INPUT,OUTPUT,TAPER0=INPUT,TAPER=TAPE4)

C
C   RAY TASKS-- INTERFACING THE RAY-METHOD WITH THE METHOD
C   OF MOMENTS
C   CASE II-- STEADY 300 MHZ TM-POLARIZED PLANE-WAVE IRRADIATION
C           OF A 14.0 CM DIAMETER, 68.5 CM LONG, OPEN-ENDED
C           CONDUCTING CYLINDER
C   OBLIQUE-INCIDENCE PLANE WAVE WITH COMPONENTS EZ AND HX
C           MODELED
C           USING SCHELKUNOFF EQUIVALENCE THEOREM FOR WILTON/
C           GLISSON M-U-N APERTURE CURRENT DATA
C   24 X 163 X 48 CELL CUBIC SPACE LATTICE IS USED
C   UNIT CELL DIAMETER = DX = 0.005 CM = WAVELENGTH/200
C   EVEN SYMMETRY ABOUT LATTICE PLANE X = 24.5*DX IS ASSUMED
C   SOFT LATTICE TRUNCATIONS ARE USED.
C   PROGRAM IS OPTIMIZED FOR THE LL( STAR-100

C
      REAL MUH,MUZ,JAMAG,JXPMA,JXSHL,JZMAG,JZPMA,JZSRC
      DIMENSION A(2542000),Z(15500),AA(1200),BDF(600),AA(48),
1          DD(24),DE(48),DF(48),CA(4),CB(4),EPS(3),SIG(3)
      DIMENSION JXMAG(1200),JXPMA(1200),JXSHL(1200),
1          JZMAG(1200),JZPMA(1200),JZSRC(1200)
      COMMON A
      DESCRIPTOR D1,D2,D3,D4,D5,D6,FLD,A1,A2,BU,BV,BW,HX,HY,HZ
      DESCRIPTOR BG
      BIT BU,BHU(600),HV,BHV(1200),BW,BHW(1200),BX,BHX(1200),
1          HY,BHY(24),HZ,BHZ(48)
      BIT BG, BFG(1200)
      ASSIGN BU,BHU(1:600)
      ASSIGN BV,BHV(1:1200)
      ASSIGN BW,BHW(1:1200)
      ASSIGN BX,BHX(1:1200)
      ASSIGN HY,BHY(1:24)
      ASSIGN HZ,BHZ(1:48)
      ASSIGN BG,BFG(1:1200)
      ASSIGN D4,DD(1:24)
      ASSIGN D5,DE(1:48)
      ASSIGN D6,DF(1:48)
      T1 = SECUND(CP)
      PRINT 150, T1
150  FORMAT(F20.5)
C
C       .....I. PROBLEM PARAMETERS.....
      FREQ = 3.0E+8
      DX = 0.005
      MPR = 3
      DATA EPS /1.0, 1.0, 1.0/
      DATA SIG /0.0, 3.7E+7, 0.61/
      NMAX = 800
C
C       .....II. BASIC AND DERIVED CONSTANTS.....
      PI = 3.14159265
      MUZ = 4.0 * PI * 1.0E-7

```

```

EPSZ = 5.854E-12
DT = DX / E.0E+0
WHALF = 0.5 / FREQ / DT
K = DT / 2.0 / EPSZ
KA = DT**2 / UX**2 / MUZ / EPSZ
KI = DT / UX / MUZ
KC = 1.0/EI
PI = 2.0 * PI * FREQ * DT
IPUN = 1

C
CA(1:4) = 0.
CH(1:4) = 0.
BX = Q8VMK0(1,25;nw)
BX = Q8VMK2(24,25;rx)
DO 2 I=1,MFR
EAF = P * SIG(I) / EPS(I)
CA(I) = (1.0 - EAF) / (1.0 + EAF)
2 CH(I) = KA / EPS(I) / (1.0 + EAF)

C
C      .....III. LOAD VECTOR A.....
C      .....ZERO INITIAL FIELDS.....
Z(1:15500) = 0.
A(1:15500) = 0.
A(2526501:15500) = 0.

C
C      .....TYPE OF MEDIUM.....
READ(60,4,END=201,ERR=201) (Z(1),I=1,600)
4 FORMAT(7HF1.0)
READ(60,4,END=201,ERR=201) (Z(1),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(1),I=2501,3100)
DO 5 J=2,13
JDEL = (J-1) * 15500
5 A(JDEL+1:15500) = Z(1:15500)
DO 6 J=152,163
JDEL = (J-1) * 15500
6 A(JDEL+1:15500) = Z(1:15500)

C
READ(60,4,END=201,ERR=201) (Z(1),I=1,600)
READ(60,4,END=201,ERR=201) (Z(1),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(1),I=2501,3100)
DO 7 J=14,150
JDEL = (J-1) * 15500
7 A(JDEL+1:15500) = Z(1:15500)

C
READ(60,4,END=201,ERR=201) (Z(1),I=1,600)
READ(60,4,END=201,ERR=201) (Z(1),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(1),I=2501,3100)
J = 151
JDEL = (J-1) * 15500
A(JDEL+1:15500) = Z(1:15500)

C
C      .....APERTURE EXCITATION.....
READ(60,15,END=201,ERR=201) (UXMAG(I),I=1,1200)

```

```

      READ(60+16+I,NID=201,ERR=201) (UXPHA(I),I=1,1200)
      READ(60+15+I,NID=201,ERR=201) (UZPHA(I),I=1,1200)
      READ(60+16+I,NID=201,ERR=201) (ULPHA(I),I=1,1200)
15   FORMAT(12F6.2,/,13F6.2)
16   FORMAT(25F3.0)

C
C      .....SYMMETRY ABOUT Z = 24.0#1A.....+
DO 12 J=2,163
JDEL = (J-1) * 1200
KMAX = 49
DO 12 JA=1,3
JH = JDEL + (JA-1)*2500 + 1
RUF(1:600) = A(JH:600)
IF (JA,FO,3) KMAX=49
A(JH+600:25) = RUF(575:25)
DO 12 K=1,24
KA = (K-1) * 25
KH = (KMAX-K) * 25
12 A(JH+KH:25) = RUF(FA+1:25)

C
C      .....MEDIA COEFFICIENTS.....+
ASSIGN A1,,DYN,1200
ASSIGN A2,,DYN,1200
ASSIGN NFD,,DYN,1200
A1 = 0.
A2 = 0.
DO 21 J=2,163
JDEL = (J-1) * 1200
DO 21 JA=1,3
JH = (JA-1)*2500 + 1
JC = JB + 1250
NFD = A(JDEL+JA:1200)
DO 20 JJ=1,MPI
RV = NFD,FN,JJ
A1 = QHVCTRL(CA(JJ),HV,A1)
20 A2 = QHVCTRL(CL(JJ),HV,A2)
A(JDEL+JE:1200) = A1
21 A(JDEL+JC:1200) = A2
FREE

C
      T2 = SECOND(CP)
      PRINT 150, T2

C      .....IV. TIME-STEPPING LOOP.....+
DO 200 N=1,NMAX
ASSIGN D1,,DYN,1200
ASSIGN D2,,DYN,1200
ASSIGN D3,,DYN,1200
C
D1 = FLOAT(N) - UXPHA(1:1200)
M0 = D1.LT.0.0
D1 = QHVCTRL(0.0,HN,D1)

```

```

D2 = D1 * RD
D3 = VSIN(D2*D3)
JXSRC(1:1200) = JXMAG(1:1200) * CR(1) * D3
C
D1 = FLOAT(N) - JZPHA(1:1200)
H0 = D1.LT.0.0
D1 = CHVCTRL(0.0+H0*0.1)
D2 = D1 * RD
D3 = VSIN(D2*D3)
JZSPC(1:1200) = JZMAG(1:1200) * CR(1) * D3
FREEE
C
MCALL = 7 + IFIX(FLOAT(N)/6.0)
IF(MCALL.GT.54) MCALL=54
C
      .....TRANSVERSE PLANE NO. 1.....
C      .....EX, EZ TRUNCATIONS.....
A(7501:1250) = A(1:1250)
A(1:1250) = A(23001:1250)
A(10201:1250) = A(1251:1250)
A(1251:1250) = A(25701:1250)
C
C      .....FY ITERATION.....
ASSIGN D1,.DYR.1174
ASSIGN D2,.DYR.1174
ASSIGN D3,.DYR.1174
C
A(8826) = 0.5 * (A(10076)+A(10077))
A(8827:22) = 0.333 * (A(10076:22)+A(10077:22)+A(10078:22))
A(8844) = 0.333 * (A(10096)+2.0*A(10099))
A(10076:24) = 4*(8851:24)
C
A(10026) = 0.5 * (A(10101)+A(10102))
A(10027:22) = 0.333 * (A(10101:22)+A(10102:22)+A(10103:22))
A(10049) = 0.333 * (A(10123)+2.0*A(10124))
A(10101:24) = 4*(10001:24)
C
D1 = CA(3) * A(8851:1174)
D2 = A(11551:1174)-A(11526:1174)+A(14201:1174)-A(14202:1174)
D3 = CR(3) * Dc
A(8851:1174) = D1 + D3
FREEE
C
      .....TRANSVERSE PLANES Z = 163.....
DO 82 JY=1,MCALL
JFPL = (JY-1) * 46500
C
      .....FX ITERATION.....
ASSIGN D1,.DYR.1173
ASSIGN D2,.DYR.1173
ASSIGN D3,.DYR.1173
C
DO 30 MA=1,3

```

```

      M = JDEL + 15500*(MA-1)

C      .....SOFT LATTICE TRUNCATIONS.....
C      A(23002+M) = 0.5 * (A(24252+M)+A(24253+M))
C      A(23003+M;21) = 0.333 * (A(24252+M;21)+A(24253+M;21)
1      +A(24254+M;21))
C      A(23024+M) = 0.5 * (A(24273+M)+A(24274+M))
C      A(24252+M;23) = A(23027+M;23)

C      A(24202+M) = 0.5 * (A(24277+M)+A(24278+M))
C      A(24203+M;21) = 0.333 * (A(24277+M;21)+A(24278+M;21)
1      +A(24279+M;21))
C      A(24224+M) = 0.5 * (A(24298+4)+A(24299))
C      A(24277+M;23) = A(24177+M;23)

C      .....MAIN EX LOOPS.....
C      D1 = A(15527+M;1173) * A(23027+M;1173)
C      D2 = A(24702+M;1173)-A(14202+M;1173)+A(26352+M;1173)
1      -A(26377+M;1173)
C      D3 = A(16777+M;1173) * D2
C      A(23027+M;1173) = D1 + D3

C      .....JX APPERTURE SOURCE CONDITION.....
C      IF(M.EQ.12*15500) A(23001+M;1200) = JXSRC(1;1200) +
1      A(23001+M;1200)

C      .....EX ENVELOPE COMPUTATION.....
C      D4 = VAABS(A(23001+M;24);1.4)
C      EY = D4.GT.A(24301+M;24)
30  A(24301+M;24) = QHVCTRL(D4,EY+A(24301+M;24))
      FREE

C      .....EY ITERATION.....
C      ASSIGN D1,.DYN.1174
C      ASSIGN D2,.DYN.1174
C      ASSIGN D3,.DYN.1174

C      DO 40 MA=1,3
M = JDEL + 15500*(MA-1)

C      .....SOFT LATTICE TRUNCATIONS.....
C      A(24326+M) = 0.5 * (A(25576+M)+A(25577+M))
C      A(24327+M;22) = 0.333 * (A(25576+M;22)+A(25577+M;22)
1      +A(25578+M;22))
C      A(24349+M) = 0.333 * (A(25598+M)+2.0*A(25599+M))
C      A(25576+M;24) = A(24351+M;24)

C      A(25526+M) = 0.5 * (A(25601+M)+A(25602+M))
C      A(25527+M;22) = 0.333 * (A(25601+M;22)+A(25602+M;22)
1      +A(25603+M;22))
C      A(25549+M) = 0.333 * (A(25623+M)+2.0*A(25624+M))
C      A(25601+M;24) = A(25501+M;24)

```

```

C      .....MAIN EY LOOPS.....
D1 = A(1E026+M;1174) * A(24351+M;1174)
D2 = A(27051+M;1174)-A(27026+M;1174)+A(24701+M;1174)
1          -A(29702+M;1174)
D3 = A(19276+M;1174) * D2
A(24351+M;1174) = D1 + D3
C
C      .....EY ENVELOPE COMPUTATION.....
D4 = VAHS(A(24426+M$24);D4)
EY = D4.GT.A(25626+M$24)
A(25626+M$24) = QHVCTRL(D4,8Y+A(25626+M$24))
C
D5 = QHVCMRHS(A(24325+M$1200),DX$D5)
D6 = VAHS(D5;D6)
E2 = D6.GT.A(25651+M$4H)
40 A(25651+M$4H) = QHVCTRL(D6,BZ+A(25651+M$40))
FFE
C
C      .....EZ ITERATION.....
ASSIGN D1..DYN.1149
ASSIGN D2..DYN.1149
ASSIGN D3..DYN.1149
C
D0 50 MA=1,3
M = JNFL + 15500*(MA-1)
C
C      .....MAIN EZ LOOPS.....
D1 = A(20501+M;1149) * A(25701+M;1149)
D2 = A(28352+M;1149)-A(28351+M;1149)+A(11526+M$1149)
1          -A(27026+M$1149)
D3 = A(21751+M;1149) * D2
A(25701+M;1149) = D1 + D3
C
C      .....EZ APERTURE SOURCE CONDITION.....
IF(M.EQ.12*15500) A(25701+M$1200) = JZSRC(1;1200) +
1          A(25701+M$1200)
C
C      .....EZ ENVELOPE COMPUTATION.....
A(26426+M$24) = 0.5 * (A(26276+M$24)+A(26301+M$24))
D4 = VAHS(A(26426+M$24);D4)
EY = D4.GT.A(26951+M$24)
A(26951+M$24) = QHVCTRL(D4,8Y+A(26951+M$24))
C
D5 = QHVCMRHS(A(25700+M$1200),DX$D5)
D6 = VAHS(D5;D6)
E2 = D6.GT.A(26976+M$4H)
50 A(26976+M$4H) = QHVCTRL(D6,BZ+A(26976+M$40))
C
C      .....HX ITERATION.....
D0 60 MA=1,3
M = JNFL + 15500*(MA-1)

```

```

C      .....MAIN HX LOOPS.....
D1 = A(11526+M;1194)
D2 = A(8851+M;1194)-A(8826+M;1194)+A(10201+M;1194)
1          -A(25701+M;1194)
A(11526+M;1194) = D1 + D2
C
C      .....HX ENVELOPE COMPUTATION.....
A(12751+M;24) = 0.5 * (A(12101+M;24)+A(12126+M;24))
D4 = VAHS(A(12751+M;24);D4)
HY = D4.GT.A(12776+M;24)
A(12776+M;24) = QHVCTRL(D4,HY+A(12776+M;24))
C
C      .....D5 = QRVCMPRS(A(11525+M;1200)+EX+D5)
D5 = VAHS(D5;D6)
HZ = D6.GT.A(12801+M;4H)
60 A(12801+M;4H) = QHVCTRL(D6,HZ+A(12801+M;4H))
FREE
C
C      .....HY ITERATION.....
ASSIGN D1..DYN.1198
ASSIGN D2..DYN.1198
C
D0 70 MA=1.3
M = JDEL + 15500*(MA-1)
C
C      .....SOFT LATTICE TRUNCATION.....
AA(1) = 0.5 * (A(29601+M)+A(29602+M))
AA(2346) = 0.333 * (A(29601+M;4H)+A(29602+M;4H)
1          +A(29603+M;4H))
AA(48) = 0.5 * (A(29647+M)+A(29648+M))
AAA(1;1200) = QBVXPMD(AA(1;1200),RW;AAA(1;1200))
A(29601+M;4H) = QRVCMPRS(A(28352+M;1200),RW+A(29601+M;4H))
C
C      .....MAIN HY LOOPS.....
D1 = A(28352+M;1198)
D2 = A(25702+M;1198)-A(25701+M;1198)+A(23002+M;1198)
1          -A(23027+M;1198)
A(28352+M;1198) = D1 + D2
C
A(28351+M;1200) = QHVCTRL(AAA(1;1200),RW+A(28351+M;1200))
A(28351+M;1200) = QHVCTRL(D.0.91A(28351+M;1200))
C
C      .....HY ENVELOPE COMPUTATION.....
A(29576+M;24) = 0.5 * (A(28420+M;24)+A(28451+M;24))
D4 = VAHS(A(29576+M;24);D4)
HY = D4.GT.A(29651+M;24)
70 A(29651+M;24) = QHVCTRL(D4,HY+A(29651+M;24))
FREE
C
C      .....HZ ITERATION.....
ASSIGN D1..DYN.1173
ASSIGN D2..DYN.1173

```

```

DO 80 MA=1,3
M = JDEL + 15500*(MA-1)
C
C      .....SOFT LATTICE TRUNCATION.....
AA(2) = 0.5 * (A(15427+M)+A(15428+M))
AA(345) = 0.333 * (A(15427+M+45)+A(15428+M+45)
               +A(15429+M+45))
1
AA(48) = 0.5 * (A(15472+M)+A(15473+M))
AAA(1;1200) = QHVXPND(AA(1;48),HW$AAA(1;1200))
A(15426+M+48) = QHVCMPRS(A(14177+M+1200),HW$A(15426+M+48))
C
C      .....MAIN MZ LOOPS.....
D1 = A(14202+M+1173)
D2 = A(23027+M+1173)-A(7527+M+1173)+A(8851+M+1173)
               -A(8852+M+1173)
1
A(14202+M+1173) = D1 + D2
C
A(14176+M+1200) = QHVCTRL(AAA(1;1200),HW$A(14176+M+1200))
A(14176+M+1200) = QHVCTRL(0.0,FX$A(14176+M+1200))
C
C      .....HZ ENVELOPE COMPUTATION.....
D4 = VAES(A(14776+M+24);D4)
DY = D4.GT.A(15476+M+24)
H0 A(15476+M+24) = QHVCTRL(D4,DY$A(15476+M+24))
FHEE
H2 CONTINUE
IF(MCALL.LE.53) GO TO 94
C
C      .....TRANSVERSE PLANE NO. 164.....
M = 162 * 15500
C
C      .....EX, EZ TRUNCATIONS.....
A(23001+M+1250) = A(15501+M+1250)
A(15501+M+1250) = A(16751+M+1250)
A(16751+M+1250) = A(7501+M+1250)
C
A(25701+M+1250) = A(18001+M+1250)
A(18001+M+1250) = A(19251+M+1250)
A(19251+M+1250) = A(10201+M+1250)
C
C      .....MX ITERATION.....
ASSIGN D1,.DYN.1144
ASSIGN D2,.DYN.1144
D1 = A(11526+M+1144)
D2 = A(HH51+M+1144)-A(HH26+M+1144)+A(10201+M+1144)
               -A(25701+M+1144)
1
A(11526+M+1144) = D1 + D2
C
A(12751+M+24) = 0.5 * (A(12101+M+24)+A(12126+M+24))
D4 = VAES(A(12751+M+24);D4)
DY = D4.GT.A(12776+M+24)
A(12776+M+24) = QHVCTRL(D4,DY$A(12776+M+24))
C

```

```

D5 = QRVCMPRS(A(11525+M$1200),EX$D5)
D6 = VAES(D5,D6)
RZ = D6.GT.A(12801+M$48)
A(12801+M$48) = QHVCTRL(D6,RZ+A(12801+M$48))
FREE

C
C      .....HZ ITERATION.....
ASSIGN U1,.DYN.1173
ASSIGN U2,.DYN.1173
AA(2) = 0.5 * (A(15427+M)+A(15428+M))
AA(3$45) = 0.333 * (A(15427+M$45)+A(15428+M$45))
1
AA(48) = 0.5 * (A(15472+M)+A(15473+M))
AAA(1$1200) = QHVXPND(AA(1$45),FW$4AA(1$1200))
A(15426+M$48) = QRVCMPRS(A(14177+M$1200),BW$4(15426+M$48))

C
D1 = A(14202+M$1173)
D2 = A(23027+M$1173)-A(7527+M$1173)+A(8551+M$1173)
1
A(14202+M$1173) = D1 + D2
A(14176+M$1200) = QHVCTRL(AAA(1$1200),BW$4(14176+M$1200))
A(14176+M$1200) = QHVCTRL(0.0,EX$A(14176+M$1200))

C
D4 = VAES(A(14776+M$24)+D4)
BY = D4.GT.A(15476+M$24)
A(15476+M$24) = QHVCTRL(D4,SY$A(15476+M$24))
FREE
94 T3 = SECOND(CP)
PRINT 150, T3

C
C      .....FIELD ENVELOPE PRINTOUT ROUTINE.....
DO 100 L=NHALF,NMAX,NHALF
IF(N.EQ.L)GO TO 101
100 CONTINUE
IF(N.EQ.NMAX)GO TO 101
GO TO 199

C
C      .....AT HORIZONTAL OBSERVATION PLANE.....
101 IF(N.EQ.NMAX)IPUN=1
IPUN = 0
PFINT 102, N
102 FORMAT(1H1,52X,27HEX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,//,2X,1HU,/)
CALL ENV(8801,20,RC,IPUN)

C
PRINT 103, N
103 FORMAT(1H1,52X,27HEY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,//,2X,1HU,/)
CALL ENV(10120,20,RC,IPUN)

C
PRINT 104, N
104 FORMAT(1H1,52X,27HEZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,//,2X,1HU,/)

```

```

      CALL ENV(11451,20,HC,IPUN)
C
      PRINT 105, N
105 FORMAT(1H1,52X,27HMX ENVELOPE FOR TIME STEP =,IS,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HU,/)
      CALL ENV(12770,20,376.7,IPUN)
C
      PRINT 106, N
106 FORMAT(1H1,52X,27HMF ENVELOPE FOR TIME STEP =,IS,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HU,/)
      CALL ENV(14151,20,376.7,IPUN)
C
      PRINT 107, N
107 FORMAT(1H1,52X,27HHZ ENVELOPE FOR TIME STEP =,IS,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HU,/)
      CALL ENV(15476,20,376.7,IPUN)
C
C       .....AT VERTICAL SYMMETRY PLANE.....
      PRINT 108, N
108 FORMAT(1H1,52X,27HHz ENVELOPE FOR TIME STEP =,IS,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HU,/)
      CALL ENV(11470,40,HC,IPUN)
C
      PRINT 109, N
109 FORMAT(1H1,52X,27HMX ENVELOPE FOR TIME STEP =,IS,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HU,/)
      CALL ENV(12801,40,376.7,IPUN)
C
      PRINT 110, N
110 FORMAT(1H1,52X,27HMEY ENVELOPE FOR TIME STEP =,IS,
1           //,62X,17HPLANE X = 24.5*DX,/,2X,1HU,/)
      CALL ENV(10151,40,HC,IPUN)
C
190 CONTINUE
200 CONTINUE
201 T4 = SECOND(CM)
      PRINT 150, T4
      STOP
      END

      SUBROUTINE FNV(LUCA,NUM,SCALE,IPUNCH)
      DIMENSION A(12542000),IP(8000),NN(50)
      COMMON A
C
      DO 1 I=1,50
1     NM(I) = 1
      IP(1;8000) = 0
C
      DO 2 LY=2,163
      LOC = LUCA + (LY-1)*15500 + 4
      LOC1 = 1 + (LY-1)*40
      IP(LOC1:NUM) = SCALE * A(LOC:NUM)
2     A(LOC:NUM) = 0.

```

```
C
IF(IPUNCH,FG,U)GO TO 5
DO 3 LY=2,163
LOCI = 1 + (LY-1)*40
LOCII = LOCI - 1 + NUM
3 WRITE(8,4) (IP(LL),LL=LOCI,LOCII)
4 FORMAT(10I6)

C
5 LXM = NUM/20
DO 8 LX=1,LXM
LXA = 1 + (LX-1)*20
LA = LXA + 4
LZ = LA + 19
DO 6 LY=2,163
LYY = 165 - LY
LOCI = LXA + (LYY-1)*40
LOCII = LOCI + 19
6 PRINT 7, LYY, (IP(LL),LL=LOCI,LOCII)
7 FORMAT(1X,I3,5X,20I6)
8 PRINT 9, (PN(LL),LL=LA+LZ)
9 FORMAT(//,8X,20I6,//////)

C
RETURN
END
```

2.7 Problem G -- Task 5, Case 3

(Section 7.4.3 of Volume 1)

The following 13 pages list the computer program for the 24 x 100 x 48 cell -- 1800 time step run of Problem G. The problem solved is a hybrid method of moments/FD-TD analysis of penetration of a 12.8 cm diameter, 28 cm long, missile guidance section by a 300 MHz plane wave at axial incidence, for the case of the interior dielectric components, metal components, and wires modeled.

```

PROGRAM FDTD(INPUT,OUTPUT,TAPE60=INPUT,TAPE8=TAPE8)
C
C RUN TASKS-- INTERFACING THE FD-TD METHOD WITH THE METHOD
C OF MOMENTS
C CASE III- STEADY 300 MHZ PLANE WAVE IRRADIATION OF A
C 12.8 CM DIAMETER MISSILE GUIDANCE SECTION
C INTERIOR METAL AND DIELECTRIC COMPONENTS MODELED
C AXIAL-INCIDENCE PLANE WAVE WITH COMPONENTS EZ AND HX MODELED
C USING SCHELKUNOFF EQUIVALENCE THEOREM FOR WILTON/
C GLISSON M-O-M APERTURE CURRENT DATA
C 24 X 100 X 48 CELL CUBIC SPACE LATTICE IS USED
C UNIT CELL DIAMETER = DX = 0.33 CM = WAVELENGTH/300
C EVEN SYMMETRY ABOUT LATTICE PLANE X = 24.5*DX IS ASSUMED
C SOFT LATTICE TRUNCATIONS ARE USED
C PROGRAM IS OPTIMIZED FOR THE LUC STAR-100
C
      REAL MUR,MUZ,JXMAG,JXPHA,JXSRC,JYMAG,JYPHA,JYSRC,JZMAG,
1      JZPHA,JZSRC
1      DIMENSION A(1565500),Z(15500),AAA(1200),BUF(600),AA(48),
1                  DD(24),DE(48),DF(48),CA(9),CH(9),EHS(9),SIG(9)
1      DIMENSION JXMAG(1200),JXPHA(1200),JXSRC(1200),
1                  JYMAG(1200),JYPHA(1200),JYSRC(1200),
2      JZMAG(1200),JZPHA(1200),JZSRC(1200)
      COMMON A
      DESCRIPTOR D1,D2,D3,D4,D5,U6,NFD,A1,A2,HU,BV,BW,HX,HY,HZ
      DESCRIPTOR HQ
      BIT BU,BBU(600),BV,BBV(1200),BW,BBW(1200),BX,BBX(1200),
1      BY,BBY(24),BZ,BBZ(48)
      BIT HQ, BBQ(1200)
      ASSIGN BU,BBU(1:600)
      ASSIGN BV,BBV(1:1200)
      ASSIGN BW,BBW(1:1200)
      ASSIGN BX,BBX(1:1200)
      ASSIGN HY,HBY(1:24)
      ASSIGN BZ,BBZ(1:48)
      ASSIGN HQ,BBQ(1:1200)
      ASSIGN D4,DD(1:24)
      ASSIGN D5,DE(1:48)
      ASSIGN D6,DF(1:48)
      T1 = SECOND(CH)
      PRINT 150, T1
150 FORMAT(F20.5)
C
C      .....I. PROBLEM PARAMETERS.....
      FREQ = 3.0E+8
      DX = 0.01/3.0
      MPR = 9
      DATA EPS /1.0, 1.0, 1.0, 5.5, 4.5, 5.3, 1.0, 1.0, 8.0/
      DATA SIG /0.0, 3.7E+7, 0.025, 0.0024, 0.0008, 0.0, 6.6E+6,
1                  3.7E+7, 0.01/
      NMAX = 1800
C

```

```

C      .....II. BASIC AND DERIVED CONSTANTS.....
PI = 3.14159265
MUZ = 4.0 * PI * 1.0E-7
EPSZ = 8.854E-12
DT = DX / 6.0E+8
NHALF = 0.5 / FREQ / DT
R = DT / 2.0 / EPSZ
RA = DT**2 / DX**2 / MUZ / EPSZ
RH = DT / DX / MUZ
RC = 1.0/RH
RD = 2.0 * PI * FREQ * DT
IPUN = 0
C
CA(1:9) = 0.
CH(1:9) = 0.
BW = Q8VMK0(1,25;HW)
HX = QHVMKZ(24,25;HX)
DO 2 I=1,MPR
EAF = R * SIG(I) / EPS(I)
CA(I) = (1.0 - EAF) / (1.0 + EAF)
2 CH(I) = RA / EPS(I) / (1.0 + EAF)
C
C      .....III. LOAD VECTOR A.....
C      .....ZERO INITIAL FIELDS.....
Z(1:15500) = 0.
A(1:15500) = 0.
A(1550001:15500) = 0.
C
C      .....TYPE OF MEDIUM.....
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
4 FORMAT(7SF1.0)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
DO 5 J=2,14
JDEL = (J-1) * 15500
5 A(JDEL+1:15500) = Z(1:15500)
C
DO 6 JA=15,71,7
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
RFAD(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
JDEL = (JA-1) * 15500
A(JDEL+1:15500) = Z(1:15500)
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
DO 6 JR=1,6
JDEL = (JA+JR-1) * 15500
6 A(JDEL+1:15500) = Z(1:15500)
DO 7 J=93,100
JDEL = (J-1) * 15500
7 A(JDEL+1:15500) = Z(1:15500)
C
READ(60,4,END=201,ERR=201) (Z(I),I=1,600)

```

```

      READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
      READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
      DO 8 J=75,77
      JDEL = (J-1) * 15500
      8 A(JDEL+1:15500) = Z(1:15500)

C
      READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
      J = 78
      JDEL = (J-1) * 15500
      A(JDEL+1:15500) = Z(1:15500)

C
      READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
      READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
      J = 79
      JDEL = (J-1) * 15500
      A(JDEL+1:15500) = Z(1:15500)

C
      READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
      READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
      READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
      DO 9 J=80,84
      JDEL = (J-1) * 15500
      9 A(JDEL+1:15500) = Z(1:15500)

C
      READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
      J = 85
      JDEL = (J-1) * 15500
      A(JDEL+1:15500) = Z(1:15500)

C
      READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
      READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
      READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
      DO 10 J=86,87
      JDEL = (J-1) * 15500
      10 A(JDEL+1:15500) = Z(1:15500)

C
      READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
      READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
      READ(60,4,END=201,ERR=201) (Z(I),I=2501,3100)
      DO 11 J=88,91
      JDEL = (J-1) * 15500
      11 A(JDEL+1:15500) = Z(1:15500)

C
      READ(60,4,END=201,ERR=201) (Z(I),I=1,600)
      READ(60,4,END=201,ERR=201) (Z(I),I=5001,5600)
      J = 92
      JDEL = (J-1) * 15500
      A(JDEL+1:15500) = Z(1:15500)

C
      .....APEKTURE EXCITATION.....
      READ(60,15,END=201,ERR=201) (JXMAG(I),I=1,625)
      READ(60,16,END=201,ERR=201) (JXPHA(I),I=1,625)
      RFAD(60,15,END=201,ERR=201) (JYMAG(I),I=1,625)

```

```

READ(60,16,END=201,ERR=201)(JYPHA(I),I=1,625)
READ(60,15,END=201,ERR=201)(JZMAG(I),I=1,625)
READ(60,16,END=201,ERR=201)(JZPHA(I),I=1,625)
15 FORMAT(12F6.2,/,13F6.2)
16 FORMAT(2SF3.0)

C
C      .....PARTIAL SYMMETRY ABOUT Z = 24.0*DX.....
DO 12 J=2,100
JDEL = (J-1) * 15500
KMAX = 49
DO 12 JA=1,3
JB = JDEL + (JA-1)*2500 + 1
BUF(1:600) = A(JB:600)
RU = BUF(1:600).GT.6.5
BUF(1:600) = QHVCTRL(3.0,RU;BUF(1:600))
IF(JA.EQ.3)KMAX=48
A(JB+600:25) = BUF(576:25)
DO 12 K=1,24
KA = (K-1) * 25
KR = (KMAX-K) * 25
12 A(JB+KR:25) = BUF(KA+1:25)

C
C      .....NON-SYMMETRIC GROUND WIRE.....
DO 13 J=43,57
JDEL = (J-1) * 15500
A(JDEL+3199) = 7.0
A(JDEL+3224) = 7.0
13 A(JDEL+5699) = 7.0

C
DO 14 K=18,28
KDEL = (K-1)*25 + 24
A(JDEL+2500+KDEL) = 7.0
A(JDEL+5000+KDEL) = 7.0
14 A(JDEL+20500+KDEL) = 7.0

C
C      .....APERTURE EXCITATION.....
DO 17 K=2,24
KA = (K-1)*25 + 1
KB = (49-K)*25 + 1
JXMAG(KB:25) = -JXMAG(KA:25)
JXPHA(KB:25) = JXPHA(KA:25)
JYMAG(KB:25) = -JYMAG(KA:25)
JYPHA(KB:25) = JYPHA(KA:25)
KA = KA - 25
JZMAG(KB:25) = JZMAG(KA:25)
17 JZPHA(KB:25) = JZPHA(KA:25)

C
C      .....MEDIA COEFFICIENTS.....
ASSIGN A1,.DYN.1200
ASSIGN A2,.DYN.1200
ASSIGN NFD,.DYN.1200
A1 = 0.
A2 = 0.

```

```

DO 21 J=2,100
JDEL = (J-1) * 15500
DO 21 JA=1,3
JB = (JA-1)*2500 + 1
JC = JB + 1250
NFD = A(JDEL+JB+1200)
DO 20 JJ=1,MPR
BV = NFD.EQ.JJ
A1 = Q8VCTRL(CA(JJ),BV$A1)
20 A2 = Q8VCTRL(CH(JJ),BV$A2)
A(JDEL+JB+1200) = A1
21 A(JDEL+JC+1200) = A2
FREE
C
T2 = SECOND(CH)
PRINT 150, T2
C
.....IV. TIME-STEPPING LOOP.....
DO 200 N=1,NMAX
ASSIGN D1..DYN.1200
ASSIGN D2..DYN.1200
ASSIGN D3..DYN.1200
C
D1 = FLOAT(N) - JXPHA(1+1200)
RQ = D1.LT.0.0
D1 = Q8VCTRL(0.0,RQ$D1)
D2 = D1 * RD
D3 = VSIN(D2*D3)
JXSRC(1+1200) = JXMAG(1+1200) * CB(1) * D3
C
D1 = FLOAT(N) - JYPHA(1+1200)
RQ = D1.LT.0.0
D1 = Q8VCTRL(0.0,RQ$D1)
D2 = D1 * RD
D3 = VSIN(D2*D3)
JYSRC(1+1200) = JYMAG(1+1200) * CB(1) * D3
C
D1 = FLOAT(N) - JZPHA(1+1200)
RQ = D1.LT.0.0
D1 = Q8VCTRL(0.0,RQ$D1)
D2 = D1 * RD
D3 = VSIN(D2*D3)
JZSRC(1+1200) = JZMAG(1+1200) * CB(1) * D3
FREE
C
MCALL = 33
C
.....TRANSVERSE PLANE NO. 1.....
.....EX, E? TRUNCATIONS.....
A(7501+1250) = A(1+1250)
A(1+1250) = A(123001+1250)
A(10201+1250) = A(1251+1250)
A(1251+1250) = A(25701+1250)

```

```

C
C      .....EY ITERATION.....
ASSIGN D1,.DYN.1174
ASSIGN D2,.DYN.1174
ASSIGN D3,.DYN.1174
C
A(8826) = 0.5 * (A(10076)+A(10077))
A(8827$22) = 0.333 * (A(10076$22)+A(10077$22)+A(10078$22))
A(8849) = 0.333 * (A(10098)+2.0*A(10099))
A(10076$24) = A(8851$24)
C
A(10026) = 0.5 * (A(10101)+A(10102))
A(10027$22) = 0.333 * (A(10101$22)+A(10102$22)+A(10103$22))
A(10049) = 0.333 * (A(10123)+2.0*A(10124))
A(10101$24) = A(10001$24)
C
D1 = CA(3) * A(8851$1174)
D2 = A(11551$1174)-A(11526$1174)+A(14201$1174)-A(14202$1174)
D3 = CB(3) * D2
A(8851$1174) = D1 + D3
FREE
C
C      .....TRANSVERSE PLANES Z = 100.....
DO 82 JY=1,MCALL
JDEL = (JY-1) * 46500
C
C      .....EX ITERATION.....
ASSIGN D1,.DYN.1173
ASSIGN D2,.DYN.1173
ASSIGN D3,.DYN.1173
C
DO 30 MA=1,3
M = JDEL + 15500*(MA-1)
C
C      .....SOFT LATTICE TRUNCATIONS.....
A(23002+M) = 0.5 * (A(24252+M)+A(24253+M))
A(23003+M$21) = 0.333 * (A(24252+M$21)+A(24253+M$21)
1               +A(24254+M$21))
A(23024+M) = 0.5 * (A(24273+M)+A(24274+M))
A(24252+M$23) = A(23027+M$23)
C
A(24202+M) = 0.5 * (A(24277+M)+A(24278+M))
A(24203+M$21) = 0.333 * (A(24277+M$21)+A(24278+M$21)
1               +A(24279+M$21))
A(24224+M) = 0.5 * (A(24298+M)+A(24299))
A(24277+M$23) = A(24177+M$23)
C
C      .....MAIN EX LOOPS.....
D1 = A(15527+M$1173) * A(23027+M$1173)
D2 = A(29702+M$1173)-A(14202+M$1173)+A(28352+M$1173)
1               -A(28377+M$1173)
D3 = A(16777+M$1173) * D2
A(23027+M$1173) = D1 + D3

```

```

C
C      .....JX APERTURE SOURCE CONDITION.....
IF(M.EQ.12*15500) A(23001+M$1200) = JXSRC(1;1200) +
1                           A(23001+M$1200)

C
C      .....EX ENVELOPE COMPUTATION.....
D4 = VAHS(A(23601+M$24)$D4)
HY = D4.GT.A(24301+M$24)
30 A(24301+M$24) = Q&VCTRL(D4,HY+A(24301+M$24))
FREE

C
C      .....EY ITERATION.....
ASSIGN D1,.DYN.1174
ASSIGN D2,.DYN.1174
ASSIGN D3,.DYN.1174

C
DO 40 MA=1,3
M = JDEL + 15500*(MA-1)

C
C      .....SOFT LATTICE TRUNCATIONS.....
A(24326+M) = 0.5 * (A(25576+M)+A(25577+M))
A(24327+M$22) = 0.333 * (A(25576+M$22)+A(25577+M$22)
1                           +A(25578+M$22))
A(24349+M) = 0.333 * (A(25598+M)+2.0*A(25599+M))
A(25576+M$24) = A(24351+M$24)

C
A(25526+M) = 0.5 * (A(25601+M)+A(25602+M))
A(25527+M$22) = 0.333 * (A(25601+M$22)+A(25602+M$22)
1                           +A(25603+M$22))
A(25549+M) = 0.333 * (A(25623+M)+2.0*A(25624+M))
A(25601+M$24) = A(25501+M$24)

C
C      .....MAIN EY LOOPS.....
D1 = A(18026+M$1174) * A(24351+M$1174)
D2 = A(27051+M$1174)-A(27026+M$1174)+A(29701+M$1174)
1                           -A(29702+M$1174)
D3 = A(19276+M$1174) * D2
A(24351+M$1174) = D1 + D3

C
C      .....JY APERTURE SOURCE CONDITION.....
IF(M.EQ.83*15500) A(24326+M$1200) = JYSRC(1;1200) +
1                           A(24326+M$1200)

C
C      .....EY ENVELOPE COMPUTATION.....
D4 = VAHS(A(24926+M$24)$D4)
HY = D4.GT.A(25626+M$24)
A(25626+M$24) = Q&VCTRL(D4,HY+A(25626+M$24))

C
D5 = Q&VCMPRS(A(24325+M$1200),HZ$D5)
D6 = VAHS(D5$D6)
HZ = D6.GT.A(25651+M$48)
40 A(25651+M$48) = Q&VCTRL(D6,HZ+A(25651+M$48))
FREE

```

```

C
C      .....EZ ITERATION.....
ASSIGN D1,,DYN.1199
ASSIGN D2,,DYN.1199
ASSIGN D3,,DYN.1199
C
DO 50 MA=1,3
M = JDEL + 15500*(MA-1)
C
C      .....MAIN EZ LOOPS.....
D1 = A(20501+M$1199) * A(25701+M$1199)
D2 = A(28352+M$1199)-A(28351+M$1199)+A(11526+M$1199)
1          -A(27026+M$1199)
D3 = A(21751+M$1199) * D2
A(25701+M$1199) = D1 + D3
C
C      .....JZ APERTURE SOURCE CONDITION.....
IF(M.EQ.12*15500) A(25701+M$1200) = JZSRC(1$1200) +
1                           A(25701+M$1200)
C
C      .....EZ ENVELOPE COMPUTATION.....
A(26926+M$24) = 0.5 * (A(26276+M$24)+A(26301+M$24))
D4 = VAHS(A(26426+M$24);D4)
BY = D4.GT.A(26951+M$24)
A(26951+M$24) = Q8VCTRL(D4,BY;A(26951+M$24))
C
D5 = Q8VCMPRS(A(25700+M$1200),HX;D5)
D6 = VABS(D5;D6)
BZ = D6.GT.A(26976+M$48)
50 A(26976+M$48) = Q8VCTRL(D6,BZ;A(26976+M$48))
C
C      .....HX ITERATION.....
DO 60 MA=1,3
M = JDEL + 15500*(MA-1)
C
C      .....MAIN HX LOOPS.....
D1 = A(11526+M$1199)
D2 = A(8851+M$1199)-A(8826+M$1199)+A(10201+M$1199)
1          -A(25701+M$1199)
A(11526+M$1199) = D1 + D2
C
C      .....HX ENVELOPE COMPUTATION.....
A(12751+M$24) = 0.5 * (A(12101+M$24)+A(12126+M$24))
D4 = VABS(A(12751+M$24);D4)
BY = D4.GT.A(12776+M$24)
A(12776+M$24) = Q8VCTRL(D4,BY;A(12776+M$24))
C
D5 = Q8VCMPRS(A(11525+M$1200),HX;D5)
D6 = VARS(D5;D6)
BZ = D6.GT.A(12801+M$48)
60 A(12801+M$48) = Q8VCTRL(D6,BZ;A(12801+M$48))
FREE
C

```

```

C      .....HY ITERATION.....
ASSIGN D1,,DYN.1148
ASSIGN D2,,DYN.1198
C
DO 70 MA=1,3
M = JDFL + 15500*(MA-1)
C
      .....SOFT LATTICE TRUNCATION.....
AA(1) = 0.5 * (A(29601+M)+A(29602+M))
AA(2+46) = 0.333 * (A(29601+M+46)+A(29602+M+46)
1
AA(48) = 0.5 * (A(29647+M)+A(29648+M))
AAA(1+1200) = Q8VXPND(AA(1+48),HW$AAA(1+1200))
A(29601+M+48) = Q8VCMPPRS(A(28352+M+1200),HW$A(29601+M+48))
C
      .....MAIN HY LOOPS.....
D1 = A(28352+M+1198)
D2 = A(25702+M+1198)-A(25701+M+1198)+A(23062+M+1198)
1
A(28352+M+1198) = D1 + D2
C
A(28351+M+1200) = Q8VCTRL(AAA(1+1200),BW$A(28351+M+1200))
A(28351+M+1200) = Q8VCTRL(0.0,BW$A(28351+M+1200))
C
      .....HY ENVELOPE COMPUTATION.....
A(29576+M+24) = 0.5 * (A(28926+M+24)+A(28951+M+24))
D4 = VABS(A(29576+M+24);D4)
HY = D4.GT.A(29651+M+24)
70 A(29651+M+24) = Q8VCTRL(D4,HY$A(29651+M+24))
FREE
C
      .....HZ ITERATION.....
ASSIGN D1,,DYN.1173
ASSIGN D2,,DYN.1173
C
DO 80 MA=1,3
M = JDEL + 15500*(MA-1)
C
      .....SOFT LATTICE TRUNCATION.....
AA(2) = 0.5 * (A(15427+M)+A(15428+M))
AA(3+45) = 0.333 * (A(15427+M+45)+A(15428+M+45)
1
AA(48) = 0.5 * (A(15472+M)+A(15473+M))
AAA(1+1200) = Q8VXPND(AA(1+48),HW$AAA(1+1200))
A(15426+M+48) = Q8VCMPPRS(A(14177+M+1200),HW$A(15426+M+48))
C
      .....MAIN HZ LOOPS.....
D1 = A(14202+M+1173)
D2 = A(23027+M+1173)-A(7527+M+1173)+A(8851+M+1173)
1
A(14202+M+1173) = D1 + D2
C
A(14176+M+1200) = Q8VCTRL(AAA(1+1200),BW$A(14176+M+1200))

```

```

A(14176+M$1200) = QHVCTRL(0.0,FX$A(14176+M$1200))
C
C      .....HZ ENVELOPE COMPUTATION.....
D4 = VAHS(A(14776+M$24)$D4)
HY = D4.GT.A(15476+M$24)
P0 A(15476+M$24) = QHVCTRL(D4,HY$A(15476+M$24))
FREE
82 CONTINUE
IF(MCALL.LT.32) GO TO 94
C
C      .....TRANSVERSE PLANE NO. 101.....
M = 99 * 15500
C
C      .....EX, EZ TRUNCATIONS.....
A(23001+M$1250) = A(15501+M$1250)
A(15501+M$1250) = A(16751+M$1250)
A(16751+M$1250) = A(7501+M$1250)
C
A(25701+M$1250) = A(18001+M$1250)
A(18001+M$1250) = A(19251+M$1250)
A(19251+M$1250) = A(10201+M$1250)
C
C      .....HX ITERATION.....
ASSIGN D1,.DYN.1199
ASSIGN D2,.DYN.1199
D1 = A(11526+M$1199)
D2 = A(8851+M$1199)-A(8826+M$1199)+A(10201+M$1199)
1                               -A(25701+M$1199)
A(11526+M$1199) = D1 + D2
C
A(12751+M$24) = 0.5 * (A(12101+M$24)+A(12126+M$24))
D4 = VAHS(A(12751+M$24)$D4)
HY = D4.GT.A(12776+M$24)
A(12776+M$24) = QHVCTRL(D4,HY$A(12776+M$24))
C
D5 = QHVCMPRS(A(11525+M$1200),FX$D5)
D6 = VAHS(D5$D6)
D7 = D6.GT.A(12801+M$48)
A(12801+M$48) = QHVCTRL(D6,D7$A(12801+M$48))
FREE
C
C      .....HZ ITERATION.....
ASSIGN U1,.DYN.1173
ASSIGN U2,.DYN.1173
AA(?) = 0.5 * (A(15427+M)+A(15428+M))
AA(3845) = 0.333 * (A(15427+M$45)+A(15428+M$45)
1                               +A(15429+M$45))
AA(48) = 0.5 * (A(15472+M)+A(15473+M))
AAA(1$1200) = QHVXPND(AA(1$48),RW$AAA(1$1200))
A(15426+M$48) = QHVCMPRS(A(14177+M$1200),RW$A(15426+M$48))
C
D1 = A(14262+M$1173)

```

```

D2 = A(23027+M$1173)-A(7527+M$1173)+A(8851+M$1173)
1 -A(8852+M$1173)
A(14202+M$1173) = D1 + D2
A(14176+M$1200) = Q8VCTRL(AAA(1$1200),HW$A(14176+M$1200))
A(14176+M$1200) = Q8VCTRL(0.0,HW$A(14176+M$1200))

C
D4 = VABS(A(14776+M$24))D4)
HY = D4.GT.A(15476+M$24)
A(15476+M$24) = Q8VCTRL(D4,HY$A(15476+M$24))
FREE
94 T3 = SECOND(CP)
PRINT 150, T3
C
C      .....FIELD ENVELOPE PRINTOUT ROUTINE.....
DO 100 L=NHALF,NMAX,NHALF
IF(N.EQ.L)GO TO 101
100 CONTINUE
IF(N.EQ.NMAX)GO TO 101
GO TO 199
C
C      .....AT HORIZONTAL OBSERVATION PLANE.....
101 IF(N.EQ.NMAX)IPUN=1
IPUN = 0
PRINT 102, N
102 FORMAT(1H1,52X,27HEX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(8801,20,HC,IPUN)
C
PRINT 103, N
103 FORMAT(1H1,52X,27HEY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(10126,20,RC,IPUN)
C
PRINT 104, N
104 FORMAT(1H1,52X,27HEZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(11451,20,RC,IPUN)
C
PRINT 105, N
105 FORMAT(1H1,52X,27HHX ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(12776,20,376.7,IPUN)
C
PRINT 106, N
106 FORMAT(1H1,52X,27HHY ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(14151,20,376.7,IPUN)
C
PRINT 107, N
107 FORMAT(1H1,52X,27HHZ ENVELOPE FOR TIME STEP =,I5,
1           //,62X,15HPLANE Z = 24*DX,/,2X,1HJ,/)
CALL ENV(15476,20,376.7,IPUN)
C

```

```

C      .....AT VERTICAL SYMMETRY PLANE.....
PRINT 108, N
108 FORMAT(1H1,52X,27HZ ENVELOPE FOR TIME STEP =,IS,
1           //,62X,17HPLANE X = 24.5*DX,/,2X+1HJ,/)
CALL ENV(11470,40,HC,IPUN)

C
PRINT 109, N
109 FORMAT(1H1,52X,27HMX ENVELOPE FOR TIME STEP =,IS,
1           //,62X,17HPLANE X = 24.5*DX,/,2X+1HJ,/)
CALL ENV(12801,40,376.7,IPUN)
CUR1 = A(49*15500+1017H) * HC * 73.33
CUR2 = A(78*15500+10161) * HC * 73.33
PRINT 150, CUR1
PRINT 150, CUR2

C
PRINT 110, N
110 FORMAT(1H1,52X,27HEY ENVELOPE FOR TIME STEP =,IS,
1           //,62X,17HPLANE X = 24.5*DX,/,2X+1HJ,/)
CALL ENV(10151,40,RC,IPUN)

C
199 CONTINUE
200 CONTINUE
201 T4 = SECOND(CP)
PRINT 150, T4
STOP
END

SUBROUTINE ENV(LOCA,NUM,SCALE,IPUNCH)
DIMENSION A(1565500),IP(4000),NN(50)
COMMON A

C
DO 1 I=1,50
1 NN(I) = I

C
DO 2 LY=2,100
LOC = LOCA + (LY-1)*15500 + 4
LOCI = 1 + (LY-1)*40
IP(LOCI:NUM) = SCALE * A(LOC:NUM)
2 A(LOC:NUM) = 0.

C
IF(IPUNCH.EQ.0)GO TO 5
DO 3 LY=2,100
LOCI = 1 + (LY-1)*40
LOCII = LOCII - 1 + NUM
3 WRITE(8,4) (IP(LL),LL=LOCI+LOCII)
4 FORMAT(10I6)

C
5 LXM = NUM/20
DO 8 LX=1,LXM
LXA = 1 + (LX-1)*20
LA = LXA + 4
LZ = LA + 19
DO 6 LY=2,100

```

```
LYY = 102 - LY
LOCI = LXA + (LYY-1)*40
LOCII = LOCI + 19
6 PRINT 7, LYY, (IP(LL),LL=LOCI,LOCII)
7 FORMAT(IX,I3,5X,20I6)
8 PRINT 9, (NN(LL),LL=LA,LZ)
9 FORMAT(//,8X,20I6,//////)
```

C

```
RETURN
END
```

3.0 DATA CARD FORMAT

3.1 Type of Medium at Each Lattice Cell

For most realistic interaction geometries, data cards are needed to specify the type of medium at each location of an electric field component. Up to 9 distinct media can be efficiently specified within a lattice using the following format.

Using the Fortran statement 4 FORMAT (75F1.0) a medium-type integer 1, 2,..., 9 can be assigned to the 600 locations of an electric field component in one plane $j = \text{constant}$ with only 8 data cards. The 600 locations are ordered as shown in Figure 1. Within the 75F1.0 format, we have:

<u>Data Card</u>	<u>Assigns Type Integer to Consecutive Locations</u>
1	1 - 75.
2	76 - 150
3	151 - 225
4	226 - 300
5	301 - 375
6	376 - 450
7	451 - 525
8	526 - 600

In all data cards, column 25, column 50, and columns 75 - 80 are left blank.

	k_{E_y}	k_{E_z}	k_{E_x}							
23	$23\frac{1}{2}$	23		576	577	578	...	598	599	600
22	$22\frac{1}{2}$	22		551	552	553	...	573	574	575
21	$21\frac{1}{2}$	21		526	527	528	...	548	549	550
.
.
.
2	$2\frac{1}{2}$	2		51	52	53	...	73	74	75
1	$1\frac{1}{2}$	1		26	27	28	...	48	49	50
0	$\frac{1}{2}$	0		1	2	3	...	23	24	25
$\frac{1}{2} \quad 1\frac{1}{2} \quad 2\frac{1}{2} \quad \dots \quad 22\frac{1}{2} \quad 23\frac{1}{2} \quad 24\frac{1}{2} \rightarrow i_{E_x}$										
$1 \quad 2 \quad 3 \quad \dots \quad 23 \quad 24 \quad 25 \rightarrow i_{E_z}$										
$1 \quad 2 \quad 3 \quad \dots \quad 23 \quad 24 \quad 25 \rightarrow i_{E_y}$										

FIGURE 1 ORDERING OF THE ELECTRIC FIELD COMPONENT LOCATIONS
IN THE LATTICE PLANE $j = \text{constant}$

3.2 Equivalent Electric Current Aperture Excitation

For the case of the hybrid method of moments/FD-TD analysis, data cards are needed to specify the Schelkunoff equivalent electric current excitation at each point in the aperture plane marked by the location of an electric field component. The electric current excitation is given in amperes/meter and is normalized (for purposes of achieving a wide-range print out) to an incident wave electric field of 10^4 volts/meter. In addition, the electric current excitation is characterized at each point by an integer number representing the number of time steps of delay of the current relative to the earliest appearance of current at any point within the aperture plane.

Using the Fortran statement 15 FORMAT (12F6.2,/,13F6.2), a current-excitation magnitude can be assigned to the 600 locations of an electric field component in one plane $j = \text{constant}$ with only 48 data cards. The 600 locations are ordered as shown in Figure 1. With this format, we have:

<u>Data Cards</u>	<u>Assigns Current Magnitude to Consecutive Locations</u>
1 and 2	1 - 25
3 and 4	26 - 50
5 and 6	51 - 75
:	:
47 and 48	576 - 600

In all data cards, the quantity 0.0 is assigned to electric field component locations either at the boundary of the aperture or outside of the aperture. In all even-numbered data cards, the quantity 0.0 is assigned to the thirteenth entry (columns 73-78).

Using the Fortran statement 16 FORMAT (25F3.0), a current-excitation delay can be assigned to the 600 locations of an electric field component in one plane $j = \text{constant}$ with only 24 data cards. The 600 locations are ordered as shown in Figure 1. With this format, we have:

AD-A092 032

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<u>Data Card</u>	<u>Assigns Current Delay to Consecutive Locations</u>
1	1 - 25
2	26 - 50
3	51 - 75
:	:
24	576 - 600

In all data cards, the quantity 0 is assigned to electric field component locations either at the boundary of the aperture or outside of the aperture. Further, in all cards, the quantity 0 is assigned to the twenty-fifth entry (columns 73-75).

REFERENCES

- [1] American National Standards Institute (ANSI) X3.9 - 1966.
- [2] STAR Fortran Language Version 2 Reference Manual. Control Data Corporation, Sunnyvale, California, 1977.

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